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PHYSICAL FEATURES OF THE COLORADO VALLEY.[1]

By Major J. W. POWELL.

I. *Mountains and Valleys.*

THE topographical features of the valley of the Colorado, or the area drained by the Colorado River and its tributaries, are, in many respects, unique, as some of these features, perhaps, are not reproduced, except to a very limited extent, on any other portion of the surface of the globe. Mountains, hills, plateaus, plains, and valleys, are here found, as elsewhere throughout the earth; but, in addition to these topographic elements in the scenic features of the region, we find buttes, outlying masses of stratified rocks, often of great altitude, not as dome-shaped or conical mounds, but usually having angular outlines; their sides are vertical walls, terraced or buttressed, and broken by deep, reëntering angles, and often naked of soil and vegetation.

Then we find lines of cliffs, abrupt escarpments of rock, of great length and great height, revealing the cut edges of strata swept away from the lower side. Thirdly, we find cañons, narrow gorges, scores or hundreds of miles in length, and hundreds or thousands of feet in depth, with walls of precipitous rocks.

In the arid region of the Western portion of the United States, there are certain tracts of country which have received the name of *Mauvaises Terres*, or Bad Lands. These are dreary wastes—naked hills, with rounded or conical forms, composed of sand, sandy clays, or fine fragments of shaly rocks, with steep slopes, and, yielding to the pressure of the foot, they are climbed only by the greatest toil, and it is a labor of no inconsiderable magnitude to penetrate or cross such a district of country. The steep hills are crowded together, and the water-ways separating them are deep *arroyas*. Where the mud-

[1] From "Report on United States Geological and Geographical Survey of the Territories. Second Division." Major J. W. Powell in charge.

rocks, or sandy clays and shales, of which the hills are composed, are interstratified with occasional harder beds, the slopes are terraced; and when these thinly-bedded, though harder, rocks prevail, the out-

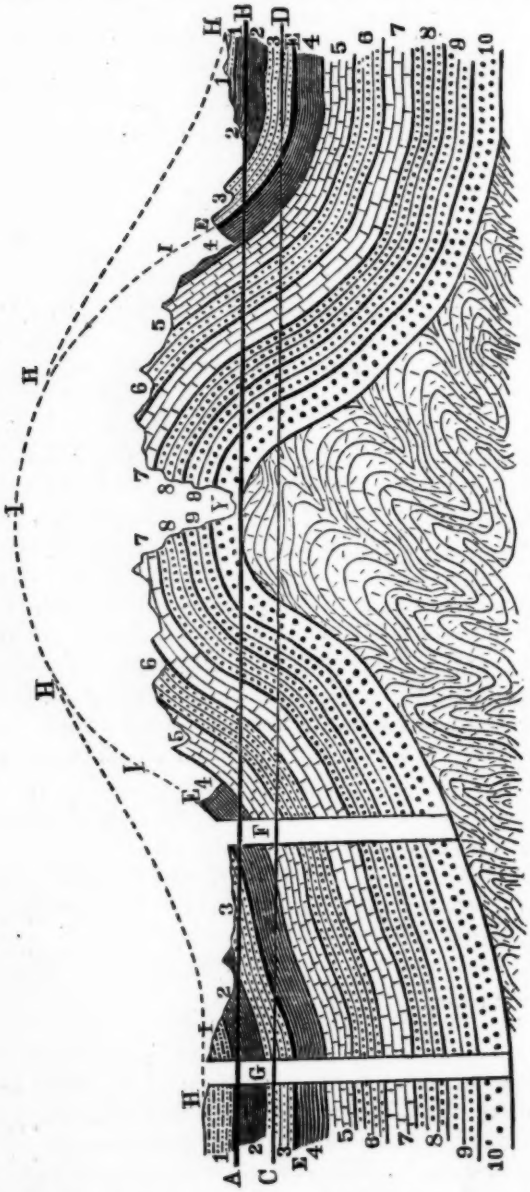


FIG. 1.—GENERALIZED SECTION THROUGH THE UINTA MOUNTAINS FROM NORTH TO SOUTH.

lines of the topography are changed, and present angular surfaces, and give rise to another type of topographic features, which I have de nominated Alcove Lands.

The agencies and conditions under which all of these features have been formed deserve mention, and in this and following chapters I shall briefly discuss this subject, in a manner as free from technical terms as will be consistent with accurate description.

The discussion will by no means be exhaustive, and I hope hereafter to treat this subject in a more thorough manner. In view of these facts, I shall not attempt any logical classification of the elements of the topography, nor of the agencies and conditions under which they were produced; but, commencing at the north, at the initial point of the exploration, I shall take them up in geographic order, as we proceed down the river.

Bad Lands and Alcove Lands north of the Uinta Mountains.—The area north of the Uinta Mountains embraced in the survey is but small. Through the middle of it runs Green River, in a deep, narrow valley, the sides or walls of which sometimes approach so near to each other, and are so precipitous, as to form a cañon.

The general surface of the country, on the north of this district, is about 1,000 feet above the river, with peaks, here and there, rising a few hundred feet higher; but south, toward the Uinta Mountains, this general surface, within a few miles of the river, gradually descends, and at the foot of the mountains we find a valley on either side, with a direction transverse to that of the course of Green River, and parallel to the mountain-range.

To the north, the water-ways are all deeply eroded; the permanent streams have flood-plains of greater or lesser extent, but the channels of the wet-weather streams, i. e., those which are dry during the greater part of the year, are narrow, and much broken by abrupt falls.

The rocks are the sediments of a dead lake, and are quite variable in lithologic characteristics. We find thinly-laminated shales, hard limestones, breaking with an angular fracture, crumbling Bad-Land rocks, and homogeneous, heavily-bedded sandstones.

The scenic features of the country are alike variable. On the cliffs about Green River City, towers and buttes are seen as you look from below, always regarded by the passing traveler as strange freaks of Nature. The limestones, interstratified with shales, give terraced and buttressed characteristics to the escarpments of the cañons and narrow valleys.

Immediately south of Bitter Creek, on the east side of Green River, there is a small district of country which we have called the Alcove Land. On the east it is drained by Little Bitter Creek, a dry gulch much of the year. This runs north into Bitter Creek, a permanent stream, which empties into the Green. The crest of this water-shed is an irregular line, only two to four miles back from the river, but usually more than 1,000 feet above it, so that the waters have a rapid descent, and every shower-born rill has excavated a deep, narrow

channel, and these narrow cañons are so close to each other as to be separated by walls of rock so steep, in most places, that they cannot be scaled, and many of these little cañons are so broken by falls as to be impassable in either direction.

The whole country is cut, in this way, into irregular, angular blocks, standing as buttresses, benches, and towers, about deep waterways and gloomy alcoves.

The conditions under which the cañons have been carved will be more elaborately discussed hereafter.

To the west of Green River, and back some miles, between Black's Fork and Henry's Fork, we have a region of buff, chocolate, and lead-colored Bad Lands. This Bad-Land country differs from the Alcove Land, above mentioned, in that its outlines are everywhere beautifully rounded, as the rocks of which it is composed crumble quickly under atmospheric agencies, so that an exposure of solid rock is rarely seen; but we have the same abrupt descent of the streams, and the same elaborate system of water-channels. Here we have loose, incoherent sandstones, shales, and clays, carved, by a net-work of running waters, into domes and cones, with flowing outlines. But still there is no vegetation, and the loose earth is naked. Occasionally, a thin stratum of harder rock will be found. Such strata will here and there form shelves or steps upon the sides of the mountains.

Traces of iron, and rarer minerals, are found in these beds, and, on exposure to the air, the chemical agencies give a greater variety of colors, so that the mountains and cones, and the strange forms of the Bad Lands, are elaborately and beautifully painted; not with the delicate tints of verdure, but with brilliant colors, that are gorgeous when first seen, but which soon pall on the senses.

The Uinta Mountains.—To the west of Green River stand the Wasatch Mountains, a system of peaks, tables, and elevated valleys, having a northerly and southerly direction, nearly parallel to the river. The range known as the Uinta Mountains stands at right angles to the Wasatch, extending toward the east, and no definite line of division can be noticed. The Wasatch is a great trunk, with a branch called the Uinta. Near the junction, the two ranges have about the same altitude, and the gulches of their summits are filled with perpetual snow; but, toward the east, the Uinta peaks are lower, gradually diminishing in altitude, until they are lost in low ridges and hills. Through this range Green River runs, and a series of cañons forms its channel.

To a person studying the physical geography of this country, without a knowledge of its geology, it would seem very strange that the river should cut through the mountains, when apparently it might have passed around them to the east, through valleys, for there are such along the north side of the Uintas, extending to the east, where the mountains are degraded to hills; and, passing around these, there

are other valleys, extending to the Green, on the south side of the range. Then, why did the river run through the mountains?

The first explanation suggested is, that it followed a previously-formed fissure through the range; but very little examination will

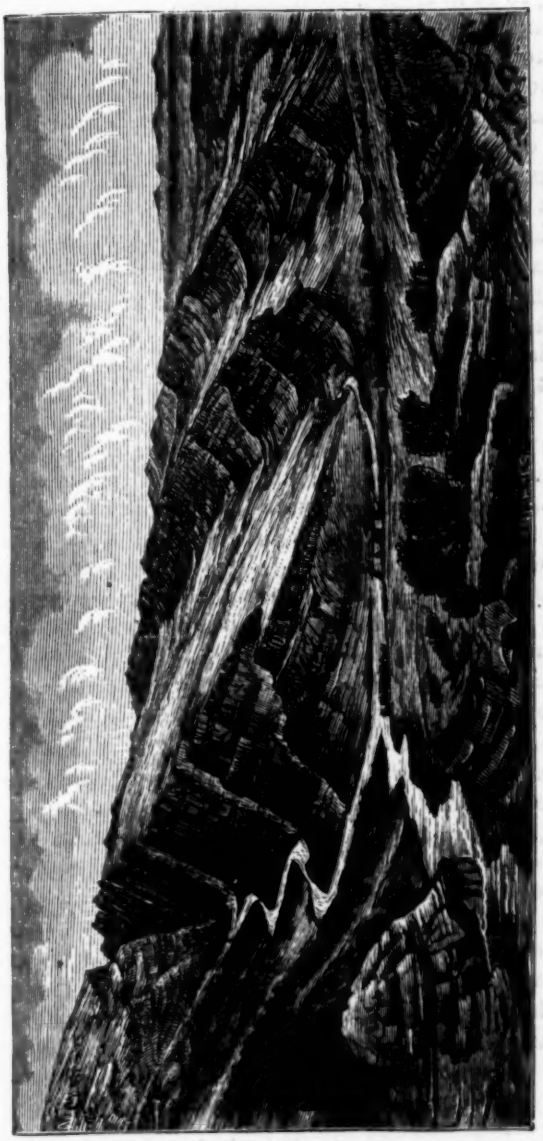


FIG. 2.—NORTHERN SLOPE OF THE UINTA MOUNTAINS, SHOWING RED CAÑON AND HOG'S BACK, WITH INTERVENING VALLEYS.

show that this explanation is unsatisfactory. The proof is abundant that the river cut its own channel; that the cañons are gorges of corrasion. Again, the question returns to us, Why did not the stream

turn around this great obstruction, rather than pass through it? The answer is, that the river had the right of way; in other words, it was running ere the mountains were formed: not before the rocks, of which the mountains are composed, were deposited, but before the formations were folded, so as to make a mountain-range.

The contracting or shriveling of the earth causes the rocks near the surface to wrinkle or fold, and such a fold was started athwart the course of the river. Had it been suddenly formed, it would have been an obstruction sufficient to turn the water in a new course to the east, beyond the extension of the wrinkle; but the emergence of the fold above the general surface of the country was little or no faster than the progress of the corrasion of the channel. We may say, then, that the river did not cut its way *down* through the mountains, from a height of many thousand feet above its present site; but, having an elevation differing but little, perhaps, from what it now has, as the fold was lifted, it cleared away the obstruction by cutting a cañon and the walls were thus elevated on either side. The river preserved its level, but mountains were lifted up; as the saw revolves on a fixed pivot, while the log through which it cuts is moved along. The river was the saw which cut the mountains in two.

Recurring to the time before this wrinkle was formed, there were beds of sandstone, shale, and limestone, more than 24,000 feet in thickness, spread horizontally over a broad stretch of this country. Then the summit of the fold slowly emerged, until the lower beds of sandstone were lifted to the altitude at first occupied by the upper beds, and if these upper beds had not been carried away, they would now be found more than 24,000 feet above the river, and we should have a billow of sandstone, with its axis lying in an easterly and westerly direction, more than 100 miles in length, 50 miles in breadth, and over 24,000 feet higher than the present altitude of the river, gently rounded from its central line above to the foot of the slope on either side. But as the rocks were lifted, rains fell upon them and gathered into streams, and the wash of the rains and the corrasion of the rivers cut the billow down almost as fast as it rose, so that the present altitude of these mountains marks only the difference between the elevation and the denudation.

It has been said that the elevation of the wrinkle was 24,000 feet, but it is probable that this is not the entire amount, for the present altitude of the river, above the sea, is nearly 6,000 feet, and when this folding began we have reason to believe that the general surface of this country was but slightly above that general standard of comparison.

Then there were down-turned as well as up-turned wrinkles, or, as the geologist would say, there were synclinal as well as anticlinal folds. Had there been no degradation of the fold, there would have been a bed of rock turned over its summit 24,000 feet above the pres-

ent level of the river. Now that bed is gone from the mountains, yet it can be seen turned up on edge against the flanks of the mountains, dipping under the beds of rocks found still farther out from the range. Follow it down, and doubtless we could trace it to a depth much below the level of the sea. While the folds were forming, the upturned flexures were cut down, and the troughs in the down-turned flexures were filled up, and we have more than 8,000 feet of these later sediments to the north of the Uinta Mountains.

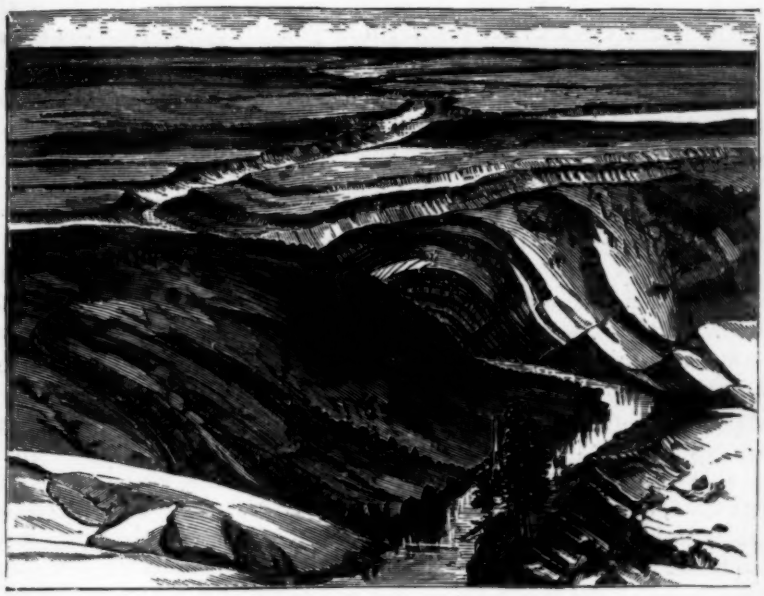


FIG. 3.—DIACLINAL VALLEY.

It will thus be seen that the upheaval was not marked by a great convulsion, for the lifting of the rocks was so slow that the rains removed the sandstones almost as fast as they came up. The mountains were not thrust up as peaks, but a great block was slowly lifted, and from this the mountains were carved by the clouds—patient artists, who take what time may be necessary for their work.

We speak of mountains forming clouds about their tops: the clouds have formed the mountains. Lift a district of granite, or marble, into their region, and they gather about it, and hurl their storms against it, beating the rocks into sands, and then they carry them out into the sea, carving out cañons, gulches, and valleys, and leaving plateaus and mountains embossed on the surface.

Instead of having a rounded billow, we have an irregular table, with beds dipping to the north, on the north side of the axis, and to the south, on the south side, and in passing over the truncated fold we pass over their upturned edges.

Go out on the flank of the fold, and find the bed of rock which would form the summit of the great wrinkle, had there been no erosion, and there sink a shaft 24,000 feet, and you will be able to study a certain succession of beds of sandstones, shales, and limestones. Go two or three miles farther from the mountains, and sink a shaft; the first 8,000 feet or more will be through sandstones and shales, unlike those seen in the first section; then you will strike the summit of the first section. Continuing down for 24,000 feet, the first will be reproduced, stratum for stratum. Now start on either side of the fold, and cross to its centre; and you will pass over the same series of strata in the same order as you would in descending the first-mentioned shaft, and in the second also, below the upper 8,000 feet. Now pass again from the centre to the flank of the fold, in either direction, and you can study the same rocks in the same order as you would in ascending these shafts. It will thus be seen that in these truncated wrinkles we are enabled to study geological formations without descending into the depths of the earth.

Fig. 1 has been constructed for the purpose of graphically expressing some of the important facts observed in the great Uinta Fold. In this, the beds are seen to turn up in a great flexure, and to be cut away above, the higher beds more than the lower; thus 4, 4–4, 4, has been cut away much more than 5, 5–5, 5; and 10, 10–10, 10 has suffered much less erosion than the beds above it. The only place where the water has carried it away is at *Y*, the bottom of the cañon.

In this diagram, the line *A–B* represents the lowest line of observation, as exhibited in the bed of the river. All below this line is theoretical. The line *C–D* represents the level of the sea. The stratum *E*, *E–E*, *E* was the last deposited antecedent to the commencement of the emergence of the summit of the fold. Had there been no erosion of the fold, the beds intervening between the broken line *I*, *I*, *I* (which is a continuation of the lines *E*, *E–E*, *E*), and the irregular line which represents the surface of the country, cutting the edges of the eroded beds, and passing through the lowest, No. 10, at *Y*, would still be found, but they have been carried away.

The diagram does not properly represent the entire amount of erosion, from the fact that the vertical scale is exaggerated, and the beds have been extended beyond their proper limits, for the purpose of representing more clearly other facts of interest.

It will be seen that in passing along the line *A–B* (the bottom of the river-channel), from the shaft *F* to the bottom of the cañon *Y*, we are able to observe the beds 4, 5, 6, 7, 8, 9, 10, in the same order that we would in descending the shaft *F*. The beds 1–1, 2–2 have been deposited since the emergence of the summit of the fold, and hence never extended quite across it; yet the lower members of these beds, doubtless, at one time extended much farther up on the flanks of the fold. They have been cut away, however, as represented in the dia-

gram. Let the lines *H*, *H–H*, *H*, represent the limit of the continuation of these beds. In the shaft *G* these beds also are exposed above those seen in shaft *F*.

The altitude of the rocks above the line of observation (*A*, *B*) is exaggerated about five times. If they were reduced to one-fifth, the proportion between the rocks seen in the various escarpments of these mountains, and those carried away below the broken lines, would be properly represented.

FIG. 4.—A CATACLINAL VALLEY

By sinking a shaft, only a little surface along the edge of the strata could be seen; but on the sides of the fold they are exposed for many miles, and often the top or bottom is cleared off for a great space, revealing even the ripple-marks of the ancient sea, or rounded impressions of rain-drops which fell in that elder time; or the sands have buried shells and bones of ancient animals, and they are still encased in the rock; and even impressions of leaves that were buried in the mud can yet be seen in such a fine state of preservation that you can trace their delicate veins.

In speaking of the great upheaval of rocks from which the Uinta Mountains are carved, I have spoken of wrinkling and folding, as if the rocks were always flexed; but these displacements are sometimes attended with fractures, on one side of which the rocks are upheaved, or thrown down on the other. Such displacements are called faults. Faults like these are seen in many places in the Uinta Mountains; one great one, on the north side, the throw of which is nearly 20,000 feet, and many others are found of lesser magnitude.

In speaking of elevation and depression by faulting or folding, it must be understood that reference is made to a change of altitude in

relation to the surface of the sea, so that upheaval or throw is only relative to this general standard of comparison. But during the geological ages represented in the folding and carving of the Uinta Mountains, it is possible the level of the sea itself has been changed by the shrinking of the earth, and a part, at least, of the apparent upheaval above mentioned may be accounted for by a depression of the formations in synclinal folds, and the letting down of broad areas of the earth's surface by lateral contraction exhibited in corrugation.

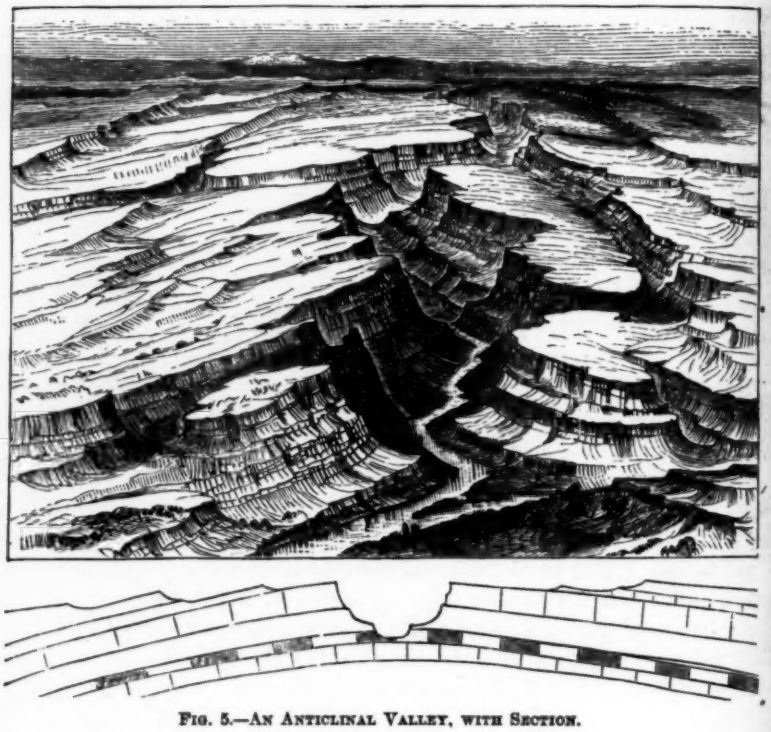


FIG. 5.—AN ANTICLINAL VALLEY, WITH SECTION.

It has already been said that the cutting off of the fold has left the upturned edges of the formations exposed to view. Some of these beds are quite hard, others are composed of very soft material; so that there are alternating beds of harder and softer rocks running in an easterly and westerly direction, both on the north and south side of the range. The soft rocks, yielding much more readily to atmospheric degradation, have been washed out in irregular valleys, between intervening ridges of harder rock, so that we have a series of nearly parallel valleys, and also a series of intervening parallel ridges, and both valleys and ridges are approximately parallel to the range. But, as the great fold of the Uinta Mountains is greatly complicated

by minor oblique and transverse flexures, while the general direction of these ridges is as described, they are turned back and forth from these lines in gentle or abrupt curves. These ridges are sometimes low mountain-ranges.

So, if we approach these mountains from either direction, north or south, we first meet with ridges, or, as they are usually called in the Western country, hog-backs. In many places these are so steep as to form a complete barrier to progress.

Usually the slope away from the side of the mountain corresponds above with the dip of the rock, and is gentle or steep, as the dip is lesser or greater. The side of the hog-back, next to the mountain, is composed of the cut edges of the strata, and varies greatly with the texture of the rocks; but usually it is steep or broken, sometimes buttressed, sometimes terraced, sometimes columned and fluted.

FIG. 6.—A SYNCLINAL VALLEY.

On the south side of the Yampa Plateau, near the head of Cliff-Creek Valley, there is an abrupt, oblique flexure, on the side of the great fold, by which the rocks are turned up, so as to stand vertically. In the rocks at this place there are two very hard conglomerates; the intervening strata are soft sandstones and marls, and have been carried away, and the conglomerates stand as vertical walls, 30 or 40 feet in thickness, 50 to 300 feet in height, and several miles in length, and between these is a broad avenue, or narrow valley, beset with ragged bowlders of conglomerate.

The drainage of these narrow valleys between the hog-backs is not always along their lengths, but the water is sometimes carried by channels crossing them and cutting through intervening ridges; hence

there are numbers of transverse streams and wet-weather channels running across valleys and through ridges.

Now, if the great axis of the Uinta Fold was everywhere the summit of a water-shed, we should find the streams heading along that irregular line running off to the flank of the fold on either side; but, as the fold is bisected by Green River, some of the minor water-courses, especially those near the river, and those near the centre of the fold, follow the strike of the rocks directly into that stream. On the north side, some head back near the summit of the fold, and run to the north, crossing the hog-backs in a direction with the dip, and then turn, at the foot of the mountains, and run into the Green, where the waters take a general southerly direction. Others, again, head back on the hog-backs, or even beyond them, on the plains and the Bad Lands to the north, and cut quite through the hog-backs and mountains in a direction against the dip of the rocks, and empty into the Green. This is especially true where the river has its easterly and westerly direction through Brown's Park. On the other side of the range, streams head high up in the mountains, and cut directly or obliquely against the upturned edges of the strata, and run in a general direction with the dip of the strata until they reach the long valleys between hog-backs; then down these valleys they turn, sometimes cutting through intervening ridges, until they find their way into the Green, where they are turned to the south, away from the mountain.

Fig. 7.—An Anaclinal Valley.

It will thus be seen that the relation of the direction of the streams to the dip of the rocks is very complex, and, for convenience of description, I have elsewhere classified these valleys, on the basis of these relations, in the following order:

Order 1.—*Transverse* valleys, having a direction at right angles to the strike.

ORDER 2.—*Longitudinal* valleys, having a direction the same as the strike.

Of the first order, three varieties are noticed:

a, *diaclinal*, those which pass through a fold. (Fig. 3.)

b, *cataclinal*, valleys that run in the direction of the dip. (Fig. 4.)

c, *anaclinal*, valleys that run against the dip of the beds. (Fig. 7.)

Of the second order, we have, also, three varieties:

A, *anticlinal* valleys, which follow anticlinal axes. (Fig. 5.)

B, *synclinal* valleys, which follow synclinal axes. (Fig. 6.)

C, *monoclinal* valleys, which run in the direction of the strike between the axes of the fold—one side of the valley formed of the summits of the beds, the other composed of the cut edges of the formation. (Fig. 8.)

Many of the valleys are thus simple in their relations to the folds; but, as we may have two systems of displacements, a valley may belong to one class, in relation to one fold, and to another in its relation to a second. Such we designate as *complex* valleys.

Again, a valley may belong to one class in one part of its course and to another elsewhere in its course. Such we designate as *compound* valleys. It will be further noticed that valleys may have many branches, but, in relegating a valley to its class, we consider only the stem of the valley proper, and not its branches.

A great diversity in the features of all these valleys is observed. Most of these modifications are due to three principal causes: First, a greater or lesser inclination of the rocks. Second, the texture of the beds—that is, their greater or lesser degree of heterogeneity. The third class of modifying influences is found in the eruptive beds.

The last-mentioned agencies are not found in the region under immediate discussion.

The explanation of the cañons of Green River will assist us in understanding the origin of the lateral valleys and cañons. The streams were there before the mountains were made; that is, the streams carved out the valleys, and left the mountains. The direction of the streams is indubitable evidence that the elevation of the fold was so slow as not to divert the streams, although the total amount of elevation was many thousands of feet. Had the fold been lifted more rapidly than the principal streams could have cut their channels, Green River would have been turned about it, and all the smaller streams and water-ways would have been cataclinal.

Thus it is that the study of the structural characteristics of the valleys and cañons teaches us, in no obscure way, the relation between the progress of upheaval and that of erosion and corrasion, showing that these latter were *pari passu* with the former, and that the agencies of Nature produce great results—results no less than the carving of a mountain-range out of a much larger block lifted from beneath

the sea; not by an extravagant and violent use of power, but by the slow agencies which may be observed generally throughout the world, still acting in the same slow, patient manner.

There are yet some interesting facts to be observed concerning these inter-hog-back valleys. Their floors are usually lower than the general surface farther away from the mountains. There seem to be two causes for this: The great fold having been lifted and truncated prior to the exposure of the rocks farther away from the mountains, its strata present their edges, instead of their upper surfaces, to the down-falling rain, and the softer beds are not so well shielded by the harder. Erosion hence progresses more rapidly than where the beds are approximately horizontal.

Again, the mountains, with peaks among the clouds, condense their moisture, and a greater quantity of rain falls on them, or in their vicinity. The region of country adjacent to the mountains re-

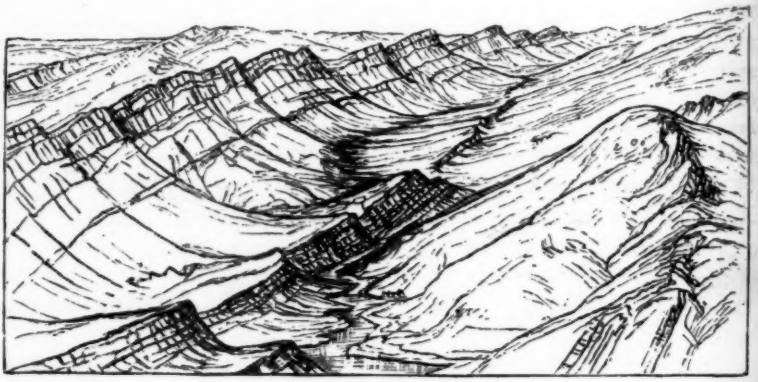


FIG. 8.—MONOCLINAL VALLEY.

ceives a portion of this extra rainfall, so that this dynamic agency increases from the plains to the summits of the mountains, probably in some direct ratio. This increase of the eroding agency, and the greater exposure of the soft beds, probably account for the fact that the lowest country is at the foot of the mountains.

There is a limit to the effect of these conditions, for it should be observed that no valley can be eroded below the level of the principal stream, which carries away the products of its surface degradation; and where the floor of such a valley has been cut down nearly to the level of such a stream, it receives the *débris* of the adjacent cliffs and mountains, and in this way the rocks composing the floor are usually masked, to a greater or lesser extent. The same topographic facts under like conditions, are found on the eastern slope of the Rocky Mountains, in Colorado Territory, and the valleys which run into the South Platte from the south, between the hog-backs, are lower than

the *mesas* and plateaus farther away from the mountains, but not lower than the flood-plain of the river.

I have endeavored above to explain the relation of the valleys of the Uinta Mountains to the stratigraphy, or structural geology, of the region, and, further, to state the conclusion reached, that the drainage was established antecedent to the corrugation or displacement of the beds by faulting and folding. I propose to call such valleys, including the orders and varieties before mentioned, *antecedent valleys.*

In other parts of the mountain-region of the West, valleys are found having directions dependent on corrugation. I propose to call these *consequent valleys.* Such valleys have been observed only in limited areas, and have not been thoroughly studied, and I omit further discussion of them.

In many cases, there can be no doubt that the present courses of the streams were determined by conditions not found in the rocks through which the channels are now carved, but that the beds in which the streams had their origin, when the district last appeared above the level of the sea, have been swept away. I propose to call such *superimposed valleys.* Thus the valleys under consideration, if classified on the basis of their relation to the rocks in which they originated, would be called *consequent valleys;* but, if classified on the basis of their relation to the rocks in which they are now found, would be called *superimposed valleys.*

THE FORM OF LIGHTNING-RODS.

By Prof. JOHN PHIN.

THE season when the attention of the public will be directed to protection from lightning is now approaching, and it is of the utmost importance that correct views in regard to the construction and erection of lightning-rods should prevail. We have in this country a class of men who have devoted themselves to the business of making money out of the fears which thunder and lightning inspire, and it unfortunately happens that the majority of these men care more for the money which they obtain than for the actual protection which they afford to their customers. To them, complicated arrangements, that can be defended with any show of reason, are a most important matter, for, on the ground of greater cost and efficiency, a more liberal harvest is obtained. In this connection there has been no more fertile source of imposition than the fallacy that lightning travels only on the surface of metallic conductors, for it has led to the construction of lightning-rods of which the cross-sections are stars, tubes, and all sorts of complicated devices. A recent note in The Popular Sci-

ENCE MONTHLY, translated from the *Comptes Rendus*, indorses this view, and, as no editorial protest has been added, it may have a tendency to mislead many. Let us, therefore, consider the facts in the case.

In looking up the history of this subject, the first mistake that we meet is the confounding of *static* with *dynamic*[1] electricity, or rather an utter ignorance of what static electricity is. The author of the note to which we have referred evidently supposes that all electricity produced by the ordinary frictional machine is *static*—which most assuredly is not the case. In making this mistake, however, he is not by any means alone. Dozens of writers have committed the same error, and it is not long since a medical man wrote a book on the curative powers of static, as distinguished from dynamic, electricity, while any physicist would have told him that in the entire volume there was not a single case described in which static electricity was used! Whenever electricity is in motion, that is to say, when it is flowing along a conductor, it is *dynamic*, no matter from what source it may be obtained. When at rest—that is, when it is in equilibrium—it is *static*. Dynamic electricity may be produced by the ordinary plate or cylinder machine; static electricity may have its origin in a voltaic battery.

Knowing that electricity at rest always tends to diffuse itself on the surface, in fact, that it always *confines* itself to the surface, it became, at an early period, a question whether electricity in motion did not follow the same law. Pouillet determined the question in a very ingenious manner. He took a cylindrical wire of a certain size and measured the resistance which it offered to a current of electricity. He then rolled the wire out flat and measured the resistance again; it was found to be the same, although it is evident that the extent of the surface of the conductor was by this means greatly increased. Other experimenters have determined the question by different methods, but always with the same result. The committee of the French Academy, which included Becquerel, De la Rive, Pouillet, and others, adopted a solid square bar as the best form for lightning-rods; and Sir William Snow Harris, though often quoted as favoring rods which present a large surface, says: "Provided the *quantity* of metal be present, the form under which we place it is evidently of no consequence to its conducting powers, since it would be absurd to suppose that a mass of metal, under any form, did not conduct electricity in all its particles; indeed, we know that it does so."

In attempting to determine this question, Pouillet and others seem always to have used electricity produced by a voltaic battery; and

[1] We give to the terms *static* and *dynamic* the old meanings, as evidently does the writer under review. According to the new definitions suggested and advocated by Profs. Thomson and Tait, dynamics includes statics. The point is one which does not affect the main question, however.

although, to the mind of every scientific physicist, such experiments are conclusive, the objection has been raised that they do not fairly determine the case for electricity of such high tension as lightning. To meet such objections, the writer of this article, many years ago, instituted the following experiments:

Take a strip of gold-leaf half an inch wide, and two or three inches long; pass through it a moderate charge from a six-jar electrical battery, and it will be entirely burned up. The circumference of the gold in this case is one inch, and this, of course, is the measure of the surface. Now, take a gold wire one-sixteenth of an inch in diameter, and pass through it the most powerful charge that can be obtained from the same battery; the wire will remain unaffected, although it presents but one-fifth the surface.

The difference between the action of static electricity and electricity in motion is very well shown by the following simple experiment: Take a large Leyden jar, one of say two gallons measurement, having the usual knob and other arrangements, as shown in the figure. In the wooden cover insert a glass tube, carrying at its upper extremity

ILLUSTRATION OF THE EFFECTS OF STATIC AND DYNAMIC ELECTRICITY.

a wire lying horizontally across it, this wire having a good-sized ball at each end, so that the discharge may take the form of a spark or an explosion, and not pass off silently. Between the horizontal wire and the knob of the jar stretch a strip of gold-leaf (*B*), and charge the jar in the usual manner. So long as the electricity does not flow *through* the gold-leaf, the latter will remain uninjured, although it is evidently charged as intensely as the machine can charge it. But, if we discharge the jar by laying one ball of the discharger on the outer coat-

ing of the jar, and the other on the knob (*A*), the gold-leaf will be destroyed. If, for the strip of gold-leaf, a wire the one-thirtieth of an inch in diameter be substituted, the charge will be carried off without its doing any damage. Here we see that, while the electricity was at rest (*static*), the gold-leaf was quite capable of receiving as heavy a charge as the most powerful machine could impart; but, the moment the electricity began to flow (became *dynamic*), the gold-leaf was destroyed, notwithstanding its great surface, while a wire of far less surface afforded a perfect way for the charge to pass off.

Experiments in this direction might be multiplied *ad infinitum*, and, when properly conducted, they all lead to the same conclusion, which is, that, when made of the same metal, the efficiency of any rod is in direct proportion to its weight per foot. It may be round, square, tubular, ribbon-like, or in the form of a rope consisting of several strands; it makes no difference. For ourselves, we give the preference to a simple flat ribbon as being most easily applied and less obtrusive, but wires and wire ropes are very convenient, more easily procured, and quite as good.

That M. Nouel has neither experimented upon the subject nor given deep thought to it, is evident from the fact that he advises us to substitute hollow pipes for the present solid rods. As the interior surface of a pipe is incapable of receiving a charge of static electricity, it is evident that, if this law applies to lightning-conductors, the capacity of a pipe or tube would be just doubled by slitting it and spreading it out flat.

THE HIGHER EDUCATION.

By F. W. CLARKE,
PROFESSOR OF CHEMISTRY AND PHYSICS, UNIVERSITY OF CINCINNATI.

EDUCATORS, to-day, are divided into two schools, especially with regard to colleges and universities. The older of these schools insists very vigorously upon the importance of thorough instruction in the so-called "dead languages," and makes all else subordinate to them. The new school, on the other hand, the school which seems to be steadily gaining ground, upholds the claims of the sciences, and gives to them the places of honor in every general course of study. The controversy between these schools is well worn, but has not yet become threadbare. The questions at issue cannot grow stale and hackneyed until after they have been finally settled.

In discussing all such questions many commonplaces must be uttered. Indeed, much confusion has arisen among educational writers because they have too timidly feared to seem commonplace. These commonplaces are the necessary, rough foundations upon which

we must build; if we ignore or lose sight of them, our structure will be unsound. Simple facts must be stated in a simple way.

The first thing to be determined is, the true object of the higher education. Is it, as some would seem to suppose, purely ornamental, a thing valuable only as far as it gives a man extra polish and elegance of mind, a mere luxury, with no practical bearings upon the every-day duties of common, busy life? Such an idea is preposterous. Of course, ornamental culture is something to be desired; its acquirement confers honor upon the acquirer; facilities should be furnished for its attainment. But true education, including all this, goes far deeper. Its purpose is to develop the mind; to strengthen the thinking faculties in every possible direction; to render the acquisition of new knowledge easier and surer; to increase the student's resources; and to render him better fitted for dealing with the useful affairs of the world. Such an education is never completed; it grows throughout a lifetime; it is self-propagating; its most valuable features are acquired outside of schools and colleges. All that a college can do is to help lay its foundations, by training the mental power for subsequent use. Which course of studies best carries out this purpose?

The argument has been summed up by certain advocates of the new school in the following very condensed way: "Science deals with things, language with words. Words merely represent things. Surely the knowledge of the thing itself is worth more than the knowledge of its symbol." But this reasoning, however sound it may be at the core, is rather too curt and dogmatic to carry conviction. No reasonable being can deny the great value of a study of language. Different races of men must exchange their ideas. A man cannot be called liberally educated who has no knowledge of any tongue other than his own. But shall linguistic studies be allowed to occupy the first rank in our college courses? Are they to almost monopolize the attention of the student, or shall they be made subordinate to other things? Ought they to be taught independently for themselves alone, or should they be brought to bear upon other studies, so that all branches of learning may be made to fortify one another? The latter view, at least as far as our colleges are concerned, is unquestionably the correct one. The study of philology, or of language by itself, is undoubtedly of great value; but it is rather a study for the specialist than for the average student. It is, certainly, a true science; only, lacking precision in its methods, and being deficient in practical applicability to the general affairs of life, it must be left out of account for the present. In a general course of study a language should be taught because of its value in opening up other departments of knowledge. It should reveal to us the thoughts of other peoples, and enable us to avail ourselves of their experience. For most men these purposes are best fulfilled by a study of the modern tongues. Latin and Greek are valuable, no doubt, only they are less indispensable than French and Ger-

man. These newer languages are not only of practical value, being spoken and written by millions of our fellow-beings to-day, but they have also many direct bearings upon all modern life. The sciences cannot be well studied without them; they open up the widest fields of recent thought; they bring us into closer harmony with the spirit of our own times. We can get along better without a knowledge of antiquity than without a knowledge of the days in which we live. The history of the siege of Troy has less interest for us than the history of the great social and economic problems which are being worked out in such deadly earnest in our own country and in Europe to-day. The ancient languages have their uses, unquestionably; so also have the Russian and the Chinese; but are those uses of sufficient importance to warrant universal study? Remembering the aims of education, we must also remember that every student has but a limited number of years to spend at college. In those few years he must acquire that learning which will best fit him to go forth and grapple with active duties. If he has both the taste and the leisure, then he can learn the dead languages after graduation. It is nothing to urge that Latin and Greek facilitate the acquisition of French and German, since the latter can be studied directly as well as the former. Few people can afford the time to study four languages in order to use but two.

If we consider the languages in their bearings upon other studies, French and German again take the lead. For advanced study in philosophy or in science these tongues are absolutely necessary, while the dead languages are not. True, many scientific terms are derived from the Latin or the Greek; but the derivation is commonly lost in new technical meanings. Moreover, the derivation, if desired, can readily be learned and sufficiently understood without much knowledge of Latin grammar or much familiarity with Greek verbs. The philological facts may be valuable, but they are no more so than a host of other facts which must, for want of time, be omitted from every general course of study. As far as concerns the Latin, needed for the comprehension of nomenclature in the natural sciences, it is safe to say that any intelligent student can learn enough of the language in three months, if, indeed, he cares to study it regularly at all.

In the direction of literary pursuits, the modern languages, again, have the advantage. Undoubtedly, the literatures of the past are rich in grand poetry, in great thoughts, and in the history of noble deeds. But poetry as grand, thoughts as great, the history of deeds as noble, can be found in the literatures of to-day. Every thing of permanent value which the old contained has been translated into the new. Plato and Virgil may be read in English, French, or German; but Goethe, Racine, and Shakespeare, are not to be found in Greek. These modern literatures are certainly of as great value in any system of real culture as those of older times. No student can master all literatures, and therefore much must be rejected. First, a scholar should study

the classics of his own language, next in order taking others of his own time. When he knows something of his fellow-beings as he will meet them in the present, then he may learn with profit about the people of two thousand years ago. We profess to admire the culture of the Greeks. This culture came, not from the study of some language dead to them, but from direct intercourse with Nature and mankind. Cannot we draw new culture from the same sources?

As far, then, as concerns direct bearing upon practical life, the modern languages must take precedence of the ancient. And, if we look at education from a utilitarian stand-point, we cannot doubt that a knowledge of those sciences which are involved in the arts, whose principles are applied in the steam-engine and in the telegraph, is of more value to the average mind than an acquaintance with the languages of antiquity. Ornament is worth having, but for most people usefulness must rank first. But another question here comes up. It is plain that a modern education best fits a man to perform the external duties of life. But which education best develops the mind? Here we come in sight of the stronghold of the classicist. He claims for his system that it affords the best mental training. Is this true?

Let us see what has to be done. Looking at education solely as a means of intellectual development, we must inquire what faculties of the mind need to be cultivated. Three may be suggested at once: the reason, the memory, and the powers of observation. The æsthetic tastes should also be brought into play, and given good material for wholesome growth. In the treatment of each faculty, education, as its name indicates, should be a drawing out rather than a cramming in. It should give the student not only material, but power; not only train him to express his thoughts, but also furnish him with thoughts to express.

Beginning with the memory by itself, it is hard to see how either system of education can outrank the other. In the old school the memory is trained upon words and grammatical rules; in the new upon facts of observation and the laws deduced from them. But, if we consider the memory in connection with the other powers of the mind, we must give the modern education the highest place. Memory and the perceptive faculty are here cultivated side by side, as they cannot be in the mere study of language. Language does nothing for the observing powers. In science, on the other hand, the eye, the ear, and all the instruments of the senses, are trained to observe facts accurately, these facts are stored up in the memory, and the memory then renders it possible to exercise the reason upon them, generalize from them, and compare them with other facts gathered from other observers.

In the cultivation of the pure reason science again takes the lead. The element of judgment, which is exercised in the work of translating, is brought into play as much among modern languages as among

the ancient. It also finds its place in the classification of observed facts. Further than this, language offers the dry, arbitrary rules of grammar as food for the intellect, while science gives grand laws and generalizations already deduced or in process of deduction. The discovery of these natural laws may be counted among the greatest achievements of the human mind. To follow out the processes by which they were discovered, gives the mind its most rigid training, and elevates the tone of thought in many other respects. The intellect becomes self-reliant and yet conscious of its own weak points. On the other hand, grammatical reasoning binds one down to past authorities, and leaves no room for original thinking. It is purely conventional, nothing more. Originality, either of thought or of investigation, is discouraged by it. The mind may be filled, but not expanded. But surely the intellect ought to be trained to think forward as well as backward, in new regions as well as in the old, beaten paths. To the scientific student the universe appears full of great unsolved problems, whose solution is the noblest exercise for the human mind and a benefit to the race. To thoughts like these the mind of the mere grammarian is closed. He sees nothing but routine, and dreads all innovation. He fetters the intellect rather than loosens it.

It may be said, however, that the old education did not depend altogether upon the languages for intellectual training; that the mathematics were included, with a variety of philosophical and historical studies. True, but the new education also includes these branches, only in a better way. Their connection with modern times is much more intimate than their connection with antiquity. Modern languages aid in their cultivation to the highest degree. In philosophy, the modern has assimilated every thing of value from the ancient; and history, in the scientific sense, is just beginning to be written. As for mathematics, the old education made it a system of mental gymnastics; the new transforms it into a useful tool which the student must apply to the solution of many physical problems. Both the intellectual value and the utility of such studies have been vastly increased.

Turning toward æsthetic studies, we find the new education again foremost. Quite obviously, the æsthetic sense must be mainly cultivated through music, works of art and literature. The world's greatest music is all modern. So also are most of the famous works of art. The painter lives entirely among the achievements of recent or comparatively recent times. As for sculpture, one needs no Latin nor Greek in order to appreciate the Laocoon. Beauty is better understood by direct contact with beauty, than by reading about it in ancient books. And in literary studies the languages of to-day are more than on a par with those of the past. This part of the argument has already been mentioned.

In scientific pursuits, also, the æsthetic tastes find such nourish-

ment as they can get nowhere else. In a truly scientific education the art of drawing is an important element, and in the study of acoustics the musician wins great advantage. But we may look in other directions than these. No one can long handle a microscope without having his sense of the beautiful enlarged; nor can any one study modern astronomy without gaining the loftiest conceptions of the sublime. The true student of Nature and her phenomena ever sees order and symmetry coming out of chaos, and finds the rarest beauty hidden where to the unaided eye naught but ugliness exists. Must it not bring the highest satisfaction to the lover of beauty thus to find its traces everywhere? Can any student, who looks upon the universe with vision thus unobscured, fail to find in his studies the truest æsthetic culture?

Theoretically, then, we may conclude that the study of science, with modern languages, literatures, and philosophies as aids, does all for the mind that the old classical education ever did, and more. A higher discipline, a higher utility, and a higher culture, are its natural results. It trains memory, intellect, the perceptive faculties, and the sense of the beautiful simultaneously, insuring a symmetrical development. It brings men into closer relations with the spirit of modern civilization, bears directly upon all modern work, aids in practical afterlife as no other education can, and helps the student to grow in all directions. This education not only fills the mind, but at the same time deepens and broadens it. In every definable respect it is superior to the old system. The latter was good enough in its day, but the new surpasses it in ours.

Yet it may be urged that all this is theory, and not borne out by facts. It is easy to point out college after college in this country in which, apparently, the classical and scientific courses have been tried side by side, to the evident disadvantage of the latter. Can this be explained?

Three things must here be taken into consideration: namely, the character of most American colleges, the character of many professed teachers, and the methods of study.

Beginning with the colleges and universities, it is noteworthy that there are to-day in our country about three hundred institutions bearing these names. Of these, Ohio has twenty-eight, while Pennsylvania, Illinois, and New York, have each twenty or over. For this deplorable scattering of educational forces, denominational rivalry is chiefly to blame. Where, by judicious management, one really efficient institution might be established, half a dozen sects, jealous of each other, build up as many insignificant weaklings. Each college acts as a drag on all the others. Libraries, cabinets, and faculties are uselessly duplicated. Naturally, one result of this state of affairs is a lowering of educational standards. It would be well for education if the several States would compel each so-called "university" to act up to its pretensions, become what it claims to be, or else forfeit its char-

ter. The educational frauds which many of these institutions perpetrate should no longer be tolerated. No new college ought to be chartered unless it has a proper endowment at the start. And, in a majority of our States, no new college should be chartered at all. Forces should be concentrated upon institutions already in existence.

But what has all this to do with the relative merits of the classics and science? Quite obviously, much. Since, on account of this foolish division of forces, most of these colleges are inadeqately endowed, they are compelled to work short-handed. One professor has frequently several branches to teach. Not long ago, in one of our Western colleges, a man was elected "professor of natural philosophy, astronomy, and the theory and practice of preaching!" In the majority of cases there is a chair of Latin, a chair of Greek, and then—a chair of "natural science!" Each linguistic professor is to some degree a specialist; while the one who teaches science is perforce compelled to be a smatterer. He is expected to teach half a dozen dissimilar branches, each one being a life-work by itself. He is to be omniscient on about $1,000 a year. Of course, in such a condition of things, the new education must suffer. No man living is able to teach properly more than one science. Indeed, some sciences, as, for example, chemistry, need to be subdivided into several different specialties, under several distinct teachers. Except by specialists, no truly scientific education can be given; since each instructor has to deal with a constantly-growing branch, and not with a fixed, completed study. The teacher must keep up with the growth of his particular science, or else drop into downright incompetency. He who is overworked by teaching several subjects cannot properly keep up with any one.

It is plain, then, that this scattering of educational forces is lowering to the character of the teacher, and that this effect is more evident and more mischievous in the wide realm of Science than in the comparatively narrow kingdom of the ancient languages. In still another way is the character of each college reflected in that of its professors. A Catholic institution will employ only Catholic instructors; a Methodist or Episcopalian university will seek out Methodists or Episcopalians; and so on. Instead of selecting teachers on the basis of capacity, the basis of belief is commonly chosen. The exceptions to this rule are rare, and are to be looked for chiefly in some of the older Eastern establishments, such as Yale, Bowdoin, Dartmouth, Union, and Columbia. This principle cannot fail to work mischief. A professor, and especially a professor of any science, should be elected because of his ability as a teacher, his knowledge, and his moral worth; not for his opinions upon some abstract theological dogma. A man may believe in sprinkling, and yet be competent to teach the chemistry of water even in a Baptist university.

One other consideration bearing upon the character of the teacher

remains to be noticed, and this will bring us naturally to the question of method. A large majority of our American college professors are graduates under the old *régime*. Having been trained in the old education, by the old methods, they are, consequently, unable to adapt themselves perfectly to the new. In the modern system, modern methods must be used. The old bottles will not hold the new wine. Formerly, instruction was given by lectures and text-book recitations; the student received, but gave nothing; he was placed upon a sort of Procrustean bedstead, and shaped according to a common pattern. The classics and mathematics were established things; the learner must take them as he found them; he was neither permitted to add nor to modify. Routine governed every thing. Differences of capacity, of tastes, and of needs, among a class of students went for nothing; there was so much raw material for the teacher to work up, and he must do it by the clumsiest rule and measure.

The new education is very different. Here we have a variety of subjects to be studied, each one best suited to a particular class of minds. The scholar who proves to be dull in one branch may be brilliant in another. Every branch is continually undergoing the changes attendant upon progress and growth. In each science new questions are continually arising; the higher we go up the mountain the wider our horizon will be. Through these changes the minds of both student and teacher are kept in constant activity; a condition requiring very different treatment from that given in the colleges of thirty years ago.

But the greatest changes in the educational method must be looked for in another direction. No longer are text-books and lectures adequate means of instruction; a new element must be brought in. This is the element of laboratory instruction. The student must not only hear about scientific truths, he must be able to demonstrate them in person. There are tools to be handled as well as books. If botany is to be studied, it must be partly in the field and partly with the microscope; if zoölogy, then the scalpel must be used; if chemistry or physics, the student must learn to perform his own experiments. Without practice of this sort the instruction will be largely thrown away. It is to science what the exercise of translation is to the study of language, or what the solution of problems is to mathematics. The student must be trained to observe for himself; then to generalize upon his observations. In no other manner can the natural and physical sciences be taught. All other teaching in them is a mere pretense. How many American colleges can boast a "scientific course" in which this method is *really* employed?

But this necessity again brings a disadvantage to science in very many institutions. A poorly-endowed college cannot afford suitable laboratories and apparatus, any more than it can afford to employ the specialists who are alone competent to manage them. Accordingly,

in four cases out of five, if not in a larger proportion, the sciences are improperly taught, by inferior or incompetent men, and therefore, as means of education, fall into disrepute. The classics have less rigorous needs, the proper teachers are more easily obtained, and thus they carry off a glory which is not rightfully theirs.

It is safe to say, in conclusion, that the new education will contrast unfavorably with the old only when it is imparted by incorrect methods or by improperly-trained teachers. The two systems, being so different, can hardly be compared upon the same ground. Let each do its own work, in its own way, with truly equal advantages, and, beyond a reasonable doubt, the new education will show the more vigor. Its greater utility, its wider range of discipline, and its more varied adaptability to dissimilar minds, unite to give it wonderful advantages.

ON THE MOTIONS OF SOUND.

By JOHN TYNDALL, F. R. S.

I.—ACOUSTIC REVERSIBILITY.

ON the 21st and 22d of June, 1822, a commission appointed by the Bureau of Longitudes of France executed a celebrated series of experiments on the velocity of sound. Two stations had been chosen, the one at Villejuif, the other at Montlhéry, both lying south of Paris, and 11.6 miles distant from each other. Prony, Mathieu, and Arago, were the observers at Villejuif, while Humboldt, Bouvard, and Gay-Lussac, were at Montlhéry. Guns, charged sometimes with three pounds of powder, were fired at both stations, and the velocity was deduced from the interval between the appearance of the flash and the arrival of the sound.

On this memorable occasion an observation was made which, as far as I know, has remained a scientific enigma to the present hour. It was noticed that while every report of the cannon fired at Montlhéry was heard with the greatest distinctness at Villejuif, by far the greater number of the reports from Villejuif failed to reach Montlhéry. Had wind existed, and had it blown from Montlhéry to Villejuif, it would have been recognized as the cause of the observed difference; but the air at the time was calm, the slight motion of translation actually existing being from Villejuif toward Montlhéry, or against the direction in which the sound was best heard.

So marked was the difference in transmissive power between the two directions that on the 22d of June while every shot fired at Montlhéry was heard *à merveille* [with wonderful distinctness] at Villejuif, but one shot out of twelve fired at Villejuif was heard, and that feebly, at the other station.

With the caution which characterized him on other occasions, and which has been referred to admiringly by Faraday,[1] Arago made no attempt to explain this anomaly. His words are: "As for the very notable differences of intensity constantly observed in the sound of the cannon accordingly as it was propagated from north to south between Villejuif and Montlhéry, or from south to north between the latter station and the former, we will not at present try to explain it, as we could present to the reader only conjectures unsupported by evidence."[2]

I have tried, after much perplexity of thought, to bring this subject within the range of experiment, and have now to submit to the Royal Society a possible solution of this enigma. The first step was to ascertain whether the sensitive flame referred to in my recent paper in the "Philosophical Transactions" could be safely employed in experiments on the mutual reversibility of a source of sound and an object on which the sound impinges. Now, the sensitive flame usually employed by me measures from eighteen to twenty-four inches in height, while the reed employed as a source of sound is less than a square quarter of an inch in area. If, therefore, the whole flame or the pipe which fed it were sensitive to sonorous vibrations, strict experiments on reversibility with the reed and flame might be difficult, if not impossible. Hence my desire to learn whether the seat of sensitiveness was so localized in the flame as to render the contemplated interchange of flame and reed permissible.

The flame being placed behind a cardboard screen, the shank of a funnel, passed through a hole in the cardboard, was directed upon the middle of the flame. The sound-waves issuing from the vibrating reed placed within the funnel produced no sensible effect upon the flame. Shifting the funnel so as to direct its shank upon the root of the flame, the action was violent.

To augment the precision of the experiment, the funnel was connected with a glass tube three feet long and half an inch in diameter, the object being to weaken by distance the effect of the waves diffracted round the edge of the funnel, and to permit those only which passed through the glass tube to act upon the flame.

Presenting the end of the tube to the orifice of the burner (*b*, Fig. 1), or the orifice to the end of the tube, the flame was violently agitated by the sounding-reed, *R*. On shifting the tube, or the burner, so as to concentrate the sound on a portion of the flame about half an inch above the orifice, the action was *nil*. Concentrating the sound upon the burner itself about half an inch below its orifice, there was no action.

These experiments demonstrate the localization of "the seat of

[1] "Researches in Chemistry and Physics," p. 484.

[2] Tyndall gives the passage in French, as found in the "Connaissance des Temps," 1825, p. 370.—Ed.

sensitiveness," and they prove the flame to be an appropriate instrument for the contemplated experiments on reversibility.

The experiments proceeded thus: The sensitive flame being placed close behind a screen of cardboard eighteen inches high by twelve inches wide, a vibrating reed, standing at the same height as the root of the flame, was placed at a distance of six feet on the other side of the screen. The sound of the reed, in this position, produced a strong agitation of the flame.

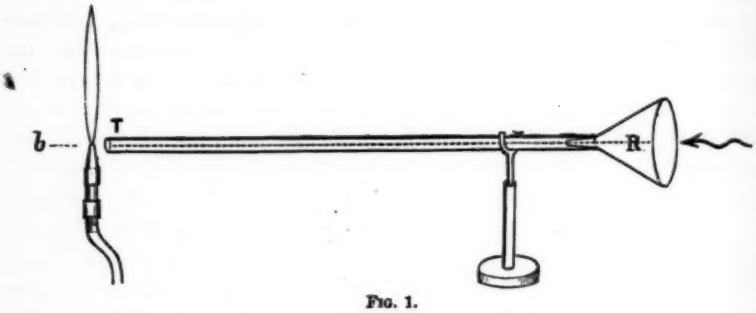


FIG. 1.

The whole upper half of the flame was here visible from the reed; hence the necessity of the foregoing experiments to prove the action of the sound on the upper portion of the flame to be *nil*, and that the waves had really to bend round the edge of the screen so as to reach the seat of sensitiveness in the neighborhood of the burner.

The positions of the flame and reed were reversed, the latter being now close behind the screen, and the former at a distance of six feet from it. The sonorous vibrations were without sensible action upon the flame.

The experiment was repeated and varied in many ways. Screens of various sizes were employed, and, instead of reversing the positions of the flame and reed, the screen was moved so as to bring, in some experiments the flame, and in other experiments the reed, close behind it. Care was also taken that no reflected sound from the walls or ceiling of the laboratory, or from the body of the experimenter, should have any thing to do with the effect. In all cases it was shown that the sound was effective when the reed was at a distance from the screen, and the flame close behind it; while the action was insensible when the positions were reversed.

Thus let *s e*, Fig. 2, be a vertical section of the screen. When the reed was at *A*, and the flame at *B*, there was no action; when the reed was at *B*, and the flame at *A*, the action was decided. It may be added that the vibrations communicated to the screen itself, and from it to the air beyond it, were without effect; for when the reed, which at *B* is effectual, was shifted to *C*, where its action on the screen was greatly augmented, it ceased to have any action on the flame at *A*.

We are now, I think, prepared to consider the failure of reversibility in the larger experiments of 1822. Happily an incidental observation of great significance comes here to our aid. It was observed and recorded at the time that while the reports of the guns at Villejuif were without echoes, a roll of echoes, lasting from twenty to twenty-five seconds, accompanied every shot at Montlhéry, being heard by the observers there. Arago, the writer of the report, referred these echoes to reflection from the clouds, an explanation which I think we are entitled to regard as problematical. The report says that "all the shots fired at Montlhéry were there *accompanied*

FIG. 2.

by a rolling sound like that of thunder."[1] I have italicized a very significant word—a word which fairly applies to our experiments on gun-sounds at the South Foreland, where there was no sensible solution of continuity between explosion and echo, but which could hardly apply to echoes coming from the clouds. For, supposing the clouds to be only a mile distant, the sound and its echo would have been separated by an interval of nearly ten seconds. But there is no mention of any interval; and, had such existed, surely the word "followed," instead of "accompanied," would have been the one employed. The echoes, moreover, appear to have been *continuous*, while the clouds observed seem to have been *separate*. "These phenomena," says Arago, "never took place except at the moment when some clouds appeared."[2] But from separate clouds a continuous roll of echoes could hardly come. When to this is added the experimental fact that clouds far denser than any ever formed in the atmosphere are demonstrably incapable of sensibly reflecting sound, while cloudless air, which Arago pronounced echoless, has been proved capable of powerfully reflecting it, I think we have strong reason to question the hypothesis of the illustrious French philosopher.

And considering the hundreds of shots fired at the South Foreland, with the attention specially directed to the aërial echoes, when no single case occurred in which echoes of measurable duration did not accompany the report of the gun, I think Arago's statement, that at Villejuif no echoes were heard when the sky was clear, must simply mean that they vanished with great rapidity. Unless the attention

[1] Tyndall quotes the French.—ED.

[2] The French quoted by Tyndall.—ED.

were specially directed to the point, a slight prolongation of the cannon-sound might well escape observation; and it would be all the more likely to do so if the echoes were so loud and prompt as to form apparently part and parcel of the direct sound.

I should be very loath to transgress here the limits of fair criticism, or to throw doubt, without good reason, on the recorded observations of an eminent man; still, taking into account what has just been stated, and remembering that the minds of Arago and his colleagues were occupied by a totally different problem (that the echoes were an incident rather than an object of observation), I think we may justly consider the sound which he called "instantaneous" as one whose aërial echoes did not differentiate themselves from the direct sound by any noticeable fall of intensity, and which rapidly died into silence.

Turning now to the observations at Montlhéry, we are struck by the extraordinary duration of the echoes heard at that station. At the South Foreland the charge habitually fired was equal to the largest of those employed by the French philosophers; but on no occasion did the gun-sounds produce echoes approaching to twenty or twenty-five seconds duration. It rarely reached half this amount. Even the siren-echoes, which were far more remarkable, more long-continued than those of the guns, never reached the duration of the Montlhéry echoes. The nearest approach to it was on the 17th of October, 1873, when the siren-echoes required fifteen seconds to subside into silence.

On this same day, moreover (and this is a point of marked significance), the transmitted sound reached its maximum range, the gun-sounds being heard at the Quenocs buoy, which is 16½ nautical miles from the South Foreland. I have already stated that the duration of the air-echoes indicates "the atmospheric depths" from which they come.[1] An optical analogy may help us here. Let light fall upon chalk, the light is wholly scattered by the superficial particles; let the chalk be powdered and mixed with water, light reaches the observer from a far greater depth of the turbid liquid. The chalk typifies the action of exceedingly dense acoustic clouds; the chalk and water that of clouds of moderate density. In the one case we have echoes of short, in the other, echoes of long duration. These considerations prepare us for the inference that Montlhéry, on the occasion referred to, must have been surrounded by a highly-diacoustic atmosphere; while the shortness of the echoes at Villejuif shows the atmosphere surrounding that station to have been acoustically opaque.

Have we any clew to the cause of the opacity? I think we have. Villejuif is close to Paris, and over it, with the observed light wind, was slowly wafted the air from the city. Thousands of chimneys to windward of Villejuif were discharging their heated currents, so that an atmosphere non-homogeneous in a high degree must have surrounded that station. At no great height in the atmosphere the equi-

[1] "Philosophical Transactions," 1874, Part I., p. 202.

librium of temperature would be established. The non-homogeneous air surrounding Villejuif is experimentally typified by our screen with the source of sound close behind it, the upper edge of the screen representing the place where equilibrium of temperature was established in the atmosphere above the station. In virtue of its proximity to the screen, the echoes from our sounding-reed would, in the case here supposed, so blend with the direct sound as to be practically indistinguishable from it, as the echoes at Villejuif followed the direct sound so hotly, and vanished so rapidly, that they escaped observation. And as our sensitive flame, at a distance, failed to be affected by the sounding body placed close behind the cardboard screen, so, I take it, did the observer at Montlhéry fail to hear the sounds of the Villejuif gun.

Something further may be done toward the experimental elucidation of this subject. The facility with which sounds pass through textile fabrics has been already illustrated,[1] a layer of cambric or calico, or even of thick flannel or baize being found competent to intercept but a fraction of the sound from a vibrating reed. Such a layer of calico may be taken to represent a layer of air differentiated from its neighbors by temperature or moisture; while a succession of such sheets of calico may be taken to represent successive layers of non-homogeneous air.

Fig. 3.

Two tin tubes (*M N* and *O P*, Fig. 3) with open ends are placed so as to form an acute angle with each other. At the end of one is the vibrating reed *r*, opposite the end of the other and in the prolongation of *P O* is the sensitive flame *f*, a second sensitive flame (*f'*) being placed in the continuation of the axis of *M N*. On sounding the reed, the direct sound through *M N* agitates the flame *f'*. Introducing the square of calico *a b* at the proper angle, a slight decrease of the action on *f'* is noticed, and the feeble echo from *a b* produces a barely perceptible agitation of the flame *f*. Adding another square, *c d*, the sound transmitted by *a b* impinges on *c d*; it is partially echoed, returns through *a b*, passes along *P O*, and still further agitates the flame *f*. Adding a third square, *e f*, the reflected sound is still further augmented, every accession to the echo being accompanied by a corre-

[1] "Philosophical Transactions," 1874, Part I., p. 208.

sponding withdrawal of the vibrations from f', and a consequent stilling of that flame.

With thinner calico or cambric it would require a greater number of layers to intercept the entire sound; hence, with such cambric we should have echoes returned from a greater distance, and therefore of greater duration. Eight layers of the calico employed in these experiments, stretched on a wire frame, and placed close together as a kind of pad, may be taken to represent a very dense acoustic cloud. Such a pad, placed at the proper angle beyond it, cuts off the sound which in its absence reaches f', almost as effectually as an impervious solid plate; the flame f' is thereby stilled, while f is far more powerfully agitated than by the reflection from a single layer. With the source of sound close at hand, the echoes from such a pad would be of insensible duration. Thus close at hand do I suppose the acoustic clouds surrounding Villejuif to have been, a similar shortness of echo being the consequence.

A further step is here taken in the illustration of the analogy between light and sound. Our pad acts chiefly by internal reflection. The sound from the reed is a composite one, made up of partial sounds, differing in pitch. If these sounds be ejected from the pad in their pristine proportions, the pad is acoustically *white;* if they return with their proportions altered, the pad is acoustically *colored.*

In these experiments my assistant, Mr. Cottrell, has rendered me material assistance.

II.—STATE OF THE RESEARCH.[1]

In preparing this new edition of "Sound," I have carefully gone over the last one, amended, as far as possible, its defects of style and matter, and paid at the same time respectful attention to the criticisms and suggestions which the former editions called forth.

The cases are few in which I have been content to reproduce what I have *read* of the works of acousticians. I have sought to make myself experimentally familiar with the ground occupied; trying, in all cases, to present the illustrations in the form and connection most suitable for educational purposes.

Though bearing, it may be, an undue share of the imperfection which cleaves to all human effort, the work has already found its way into the literature of various nations of diverse intellectual standing. Last year, for example, a new German edition was published "under the special supervision" of Helmholtz and Wiedemann. That men so eminent, and so overladen with official duties, should add to these the labor of examining and correcting every proof-sheet of a work like this, shows that they consider it to be what it was meant to be—a serious attempt to improve the public knowledge of science. It is especially gratifying to me to be thus assured that not in England

[1] Preface to forthcoming third edition of "Sound." By John Tyndall, F. R. S.

alone has the book met a public want, but also in that learned land to which I owe my scientific education.

Before me, on the other hand, lie two volumes, of foolscap size, curiously stitched, and printed in characters the meaning of which I am incompetent to penetrate. Here and there, however, I notice the familiar figures of the former editions of "Sound." For these volumes I am indebted to Mr. John Fryer, of Shanghai, who, along with them, favored me, a few weeks ago, with a letter, from which the following is an extract: "One day," writes Mr. Fryer, "soon after the first copy of your work on 'Sound' reached Shanghai, I was reading it in my study, when an intelligent official, named Hsii-chung-hu, noticed some of the engravings, and asked me to explain them to him. He became so deeply interested in the subject of Acoustics, that nothing would satisfy him but to make a translation. Since, however, engineering and other works were then considered to be of more practical importance by the higher authorities, we agreed to translate your work during our leisure time every evening, and publish it separately ourselves. Our translation, however, when completed, and shown to the higher officials, so much interested them and pleased them, that they at once ordered it to be published at the expense of the Government, and sold at cost price. The price is four hundred and eighty copper cash per copy, or about one shilling and eightpence. This will give you an idea of the cheapness of native printing." Mr. Fryer adds that his Chinese friend had no difficulty in grasping every idea in the book.

The new matter of greatest importance which has been introduced into this edition is an account of an investigation which, during the two past years, I have had the honor of conducting in connection with the Elder Brethren of the Trinity House. Under the title "Researches on the Acoustic Transparency of the Atmosphere, in relation to the Question of Fog-signaling," the subject is treated in Chapter VII. of this volume. It was only by governmental appliances that such an investigation could have been made; and it gives me pleasure to believe that not only have the practical objects of the inquiry been secured, but that a crowd of scientific errors, which for more than a century and a half have surrounded this subject, have been removed, their place being now taken by the sure and certain truth of Nature. In drawing up the account of this laborious inquiry, I aimed at linking the observations so together, that they alone should offer a substantial demonstration of the principles involved. Further labors enabled me to bring the whole inquiry within the firm grasp of *experiment*, and thus to give it a certainty which, without this final guarantee, it could scarcely have enjoyed.

Immediately after the publication of the first brief abstract of the investigation, it was subjected to criticism. To this I did not deem

it necessary to reply, believing that the grounds of it would disappear in presence of the full account. The only opinion to which I thought it right to defer was to some extent a private one, communicated to me by Prof. Stokes. He considered that I had, in some cases, ascribed too exclusive an influence to the mixed currents of aqueous vapor and air, to the neglect of differences of temperature. That differences of temperature, when they come into play, are an efficient cause of acoustic opacity, I never doubted. In fact, aërial reflection arising from this cause is, in the present inquiry, for the first time made the subject of experimental demonstration. What the relative potency of differences of temperature and differences due to aqueous vapor, in the cases under consideration, may be, I do not venture to state; but, as both are active, I have, in Chapter VII., referred to them jointly as concerned in the production of those "acoustic clouds" to which the stoppage of sound in the atmosphere is for the most part due.

Subsequently, however, to the publication of the full investigation, another criticism appeared, to which, in consideration of its source, I would willingly pay all respect and attention. In this criticism, which reached me first through the columns of an American newspaper, differences in the amounts of aqueous vapor, and differences of temperature, are alike denied efficiency as causes of acoustic opacity. At a meeting of the Philosophical Society of Washington, the emphatic opinion had, it was stated, been expressed that I was wrong in ascribing the opacity of the atmosphere to its flocculence, the really efficient cause being *refraction*. This view appeared to me so obviously mistaken that I assumed, for a time, the incorrectness of the newspaper account.

Recently, however, I have been favored with the "Report of the United States Lighthouse Board for 1874," in which the account just referred to is corroborated. A brief reference to this report will here suffice. Major Elliott, the accomplished officer and gentleman referred to at page 261, had published a record of his visit of inspection to this country, in which he spoke, with a perfectly enlightened appreciation of the facts, of the differences between our system of lighthouse illumination and that of the United States. He also embodied in his report some account of the investigation on fog-signals, the initiation of which he had witnessed, and indeed aided, at the South Foreland.

On this able report of their own officer the Lighthouse Board at Washington make the following remark: "Although this account is interesting in itself and to the public generally, yet, being addressed to the Lighthouse Board of the United States, it would tend to convey the idea that the facts which it states were new to the Board, and that the latter had obtained no results of a similar kind; while a reference to the Appendix to this Report[1] will show that the researches of our

[1] It will be borne in mind that the Washington Appendix was published nearly a year after my Report to the Trinity House.

Lighthouse Board have been much more extensive on this subject than those of the Trinity House, and that the latter has established no facts of practical importance which had not been previously observed and used by the former."

The "Appendix" here referred to is from the pen of the venerable Prof. Joseph Henry, chairman of the Lighthouse Board at Washington. To his credit be it recorded that, at a very early period in the history of fog-signaling, Prof. Henry reported in favor of Daboll's trumpet, though he was opposed by one of his colleagues on the ground that "fog-signals were of little importance, since the mariner should know his place by the character of his soundings." In the Appendix, he records the various efforts made in the United States with a view to the establishment of fog-signals. He describes experiments on bells, and on the employment of reflectors to reënforce their sound. These, though effectual close at hand, were found to be of no use at a distance. He corrects current errors regarding steam-whistles, which by some inventors were thought to act like ringing bells. He cites the opinion of the Rev. Peter Ferguson, that sound is better heard in fog than in clear air. This opinion is founded on observations of the noise of locomotives; in reference to which it may be said that others have drawn from similar experiments diametrically opposite conclusions. On the authority of Captain Keeney he cites an occurrence, "in the first part of which the captain was led to suppose that fog had a marked influence in deadening sound, though in a subsequent part he came to an opposite conclusion." Prof. Henry also describes an experiment made during a fog at Washington, in which he employed "a small bell rung by clock-work, the apparatus being the part of a moderator lamp intended to give warning to the keepers when the supply of oil ceased. The result of the experiment was, he affirms, contrary to the supposition of absorption of the sound by the fog." This conclusion is not founded on comparative experiments, but on observations made in the fog alone; "for," adds Prof. Henry, "the change in the condition of the atmosphere, as to temperature and the motion of the air, before the experiment could be repeated in clear weather, rendered the result not entirely satisfactory."

This, I may say, is the only experiment on fog which I have found recorded in the Appendix.

In 1867 the steam-siren was mounted at Sandy Hook, and examined by Prof. Henry. He compared its action with that of a Daboll trumpet, employing for this purpose a stretched membrane covered with sand, and placed at the small end of a tapering tube which concentrated the sonorous motion upon the membrane. The siren proved most powerful. "At a distance of 50, the trumpet produced a decided motion of the sand, while the siren gave a similar result at a distance of 58." Prof. Henry also varied the pitch of the siren, and found that, in association with its trumpet, 400 impulses per second yielded the

maximum sound; while the best result with the unaided siren was obtained when the impulses were 360 a second. Experiments were also made on the influence of pressure; from which it appeared that, when the pressure varied from 100 lbs. to 20 lbs., the distance reached by the sound (as determined by the vibrating membrane) varied only in the ratio of 61 to 51. Prof. Henry also showed the sound of the fog-trumpet to be independent of the material employed in its construction; and he furthermore observed the decay of the sound when the angular distance from the axis of the instrument was increased. Further observations were made by Prof. Henry and his colleagues in August, 1873, and in August and September, 1874. In the brief but interesting account of these experiments an hypothetical element appears, which is absent from the record of the earlier observations.

It is quite evident from the foregoing that, in regard to the question of fog-signaling, the Lighthouse Board of Washington have not been idle. Add to this the fact that their eminent chairman gives his services gratuitously, conducting without fee or reward experiments and observations of the character here revealed, and I think it will be conceded that he not only deserves well of his own country, but also sets his younger scientific contemporaries, both in his country and ours, an example of high-minded devotion.

I was quite aware, in a general way, that labors like those now for the first time made public had been conducted in the United States, and this knowledge was not without influence upon my conduct. The first instruments mounted at the South Foreland were of English manufacture; and I, on various accounts, entertained a strong sympathy for their able constructor, Mr. Holmes. From the outset, however, I resolved to suppress such feelings, as well as all other extraneous considerations, individual or national, and to aim at obtaining the best instruments, irrespective of the country which produced them. In reporting, accordingly, on the observations of May 19 and 20, 1873 (our first two days at the South Foreland), these were my words to the Elder Brethren of the Trinity House:

"In view of the reported performance of horns and whistles in other places, the question arises whether those mounted at the South Foreland, and to which the foregoing remarks refer, are of the best possible description. . . . I think our first duty is to make ourselves acquainted with the best instruments hitherto made, no matter where made; and then, if home genius can transcend them, to give it all encouragement. Great and unnecessary expense may be incurred, through our not availing ourselves of the results of existing experience.

"I have always sympathized, and I shall always sympathize, with the desire of the Elder Brethren to encourage the inventor who first made the magneto-electric light available for lighthouse purposes. I regard his aid and counsel as, in many respects, invaluable to the corporation. But however original he may be, our duty is to demand that his genius shall be expended in making advances on that which has been already achieved elsewhere. If the whistles and horns that we heard on the 19th and 20th be the very best hitherto constructed, my

views have been already complied with; but if they be not—and I am strongly inclined to think that they are not—then I would submit that it behooves us to have the best, and to aim at making the South Foreland, both as regards light and sound, a station not excelled by any other in the world."

On this score it gives me pleasure to say that I never had a difficulty with the Elder Brethren. They agreed with me; and two powerful steam-whistles, the one from Canada, the other from the United States, together with the steam-siren—also an American instrument—were in due time mounted at the South Foreland. It will be seen, in Chapter VII., that my strongest recommendation applies to an instrument for which we are indebted to the United States.

In presence of these facts, it will hardly be assumed that I wish to withhold from the Lighthouse Board of Washington any credit that they may fairly claim. My desire is to be strictly just; and this desire compels me to express the opinion that their report fails to establish the inordinate claim made in its first paragraph. It contains observations, but contradictory observations; while, as regards the establishment of any principle which should reconcile the conflicting results, it leaves our condition unimproved.

But I willingly turn aside from the discussion of "claims" to the discussion of science. Inserted, as a kind of intrusive element, into the Report of Prof. Henry, is a second Report by General Duane, founded on an extensive series of observations made by him in 1870 and 1871. After stating with distinctness the points requiring decision, the general makes the following remarks:

"Before giving the results of these experiments, some facts will be stated which will explain the difficulties of determining the power of a fog-signal.

"There are six steam fog-whistles on the coast of Maine: these have been frequently heard at a distance of twenty miles, and as frequently cannot be heard at the distance of two miles, and this with no perceptible difference in the state of the atmosphere.

"The signal is often heard at a great distance in one direction, while in another it will be scarcely audible at the distance of a mile. This is not the effect of wind, as the signal is frequently heard much farther against the wind than with it.[1] For example, the whistle on Cape Elizabeth can always be distinctly heard in Portland, a distance of nine miles, during a heavy northeast snowstorm, the wind blowing a gale directly from Portland toward the whistle.[2]

"The most perplexing difficulties, however, arise from the fact that the signal often appears to be surrounded by a belt, varying in radius from one to one and a half mile, from which the sound appears to be entirely absent. Thus, in moving directly from a station the sound is audible for the distance of a mile, is then lost for about the same distance, after which it is again distinctly heard for

[1] That is to say, homogeneous air with an opposing wind is frequently more favorable to sound than non-homogeneous air with a favoring wind. We made the same experience at the South Foreland.—J. T.

[2] Had this observation been published, it could only have given me pleasure to refer to it in my recent writings. It is a striking confirmation of my observations on the Mer de Glace in 1859.

a long time. This action is common to all ear-signals, and has been at times observed at all the stations, at one of which the signal is situated on a bare rock twenty miles from the main-land, with no surrounding objects to affect the sound."

It is not necessary to assume here the existence of a "belt," at some distance from the station. The passage of an acoustic cloud over the station itself would produce the observed phenomenon.

Passing over the record of many other valuable observations, in the Report of General Duane, I come to a few very important remarks which have a direct bearing upon the present question:

"From an attentive observation," writes the general, "during three years, of the fog-signals on this coast, and from the reports received from the captains and pilots of coasting-vessels, I am convinced that, in some conditions of the atmosphere, the most powerful signals will be at times unreliable.[1]

"Now it frequently occurs that a signal, which under ordinary circumstances would be audible at a distance of fifteen miles, cannot be heard from a vessel at the distance of a single mile. This is probably due to the reflexion mentioned by Humboldt.

"The temperature of the air over the land where the fog-signal is located being very different from that over the sea, the sound, in passing from the former to the latter, undergoes reflexion at their surface of contact. The correctness of this view is rendered more probable by the fact that, when the sound is thus impeded in the direction of the sea, it has been observed to be much stronger inland.

"Experiments and observation lead to the conclusion that these anomalies in the penetration and direction of sound from fog-signals are to be attributed mainly to the want of uniformity in the surrounding atmosphere, and that snow, rain, and fog, and the direction of the wind, have much less influence than has been generally supposed."

The Report of General Duane is marked throughout by fidelity to facts, rare sagacity, and soberness of speculation. The last three of the paragraphs just quoted exhibit, in my opinion, the only approach to a true explanation of the phenomena which the Washington Report reveals. At this point, however, the eminent chairman of the Lighthouse Board strikes in with the following criticism:

"In the foregoing I differ entirely in opinion from General Duane, as to the cause of extinction of powerful sounds being due to the unequal density of the atmosphere. The velocity of sound is not at all affected by barometric pressure; but if the difference in pressure is caused by a difference in heat, or by the expansive power of vapor mingled with the air, a slight degree of obstruction of sound may be observed. But this effect we think is entirely too minute to produce the results noted by General Duane and Dr. Tyndall, while we shall find in the action of currents above and below a true and efficient cause."

I have already cited the remarkable observation of General Duane, that, with a snow-storm from the northeast blowing against the sound,

[1] Had I been aware of its existence I might have used the language of General Duane to express my views on the point here adverted to. (*See* chapter vii., pp. 319, 320.)

the signal at Port Elizabeth is always heard at Portland, a distance of nine miles. The observations at the South Foreland, where the sound has been proved to reach a distance of more than twelve miles against the wind, backed by decisive experiments, reduce to certainty the surmises of General Duane. It has, for example, been proved that a couple of gas-flames placed in a chamber can, in a minute or two, render its air so non-homogeneous as to cut a sound practically off; while the same sound passes without sensible impediment through showers of paper-scraps, seeds, bran, rain-drops, and through fumes and fogs of the densest description. The sound also passes through thick layers of calico, silk, serge, flannel, baize, close felt, and through pads of cotton-net impervious to the strongest light.

As long indeed as the air on which snow, hail, rain, or fog, is suspended is homogeneous, so long will sound pass through the air, sensibly heedless of the suspended matter.[1] This point is illustrated upon a large scale by my own observations on the Mer de Glace, and by those of General Duane, at Portland, which prove the snow-laden air from the northeast to be a highly homogeneous medium. Prof. Henry thus accounts for the fact that the northeast snow-wind renders the sound of Cape Elizabeth audible at Portland: In the higher regions of the atmosphere he places an ideal wind, blowing in a direction opposed to the real one, which *always* accompanies the latter, and which more than neutralizes its action. In speculating thus he bases himself on the reasoning of Prof. Stokes, according to which a sound-wave moving against the wind is tilted upward. The upper and opposing wind is invented for the purpose of tilting again the already lifted sound-wave downward. Prof. Henry does not explain how the sound-wave recrosses the hostile lower current, nor does he give any definite notion of the conditions under which it can be shown that it will reach the observer.

This, so far as I know, is the only theoretic gleam cast by the Washington Report on the conflicting results which have hitherto rendered experiments on fog-signals so bewildering. I fear it is an *ignis fatuus*, instead of a safe guiding light. Prof. Henry, however, boldly applies the hypothesis in a variety of instances. But he dwells with particular emphasis upon a case of non-reciprocity which he considers absolutely fatal to my views regarding the flocculence of the atmosphere. The observation was made on board the steamer City of Richmond, during a thick fog in a night of 1872. "The vessel was approaching Whitehead from the southwestward, when, at a distance of about six miles from the station, the fog-signal, which is a ten-inch steam-whistle, was distinctly perceived, and continued to be heard with increasing intensity of sound until within about three miles, when the sound suddenly ceased to be heard, and was not perceived again until the vessel approached within a quarter of a mile of the sta-

[1] This is not more surprising than the passage of radiant heat through rock-salt.

tion, although from conclusive evidence, furnished by the keeper, it was shown that the signal had been sounding during the whole time."

But, while the ten-inch shore-signal thus failed to make itself heard at sea, a six-inch whistle, on board the steamer, made itself heard on shore. Prof. Henry thus turns this fact against me: "It is evident," he writes, "that this result could not be due to any mottled condition or want of acoustic transparency in the atmosphere, since this would absorb the sound equally in both directions." Had the observation been made in a still atmosphere, this argument would, at one time, have had great force. But the atmosphere was not still, and a sufficient reason for the observed non-reciprocity is to be found in the recorded fact that the wind was blowing against the shore-signal, and in favor of the ship-signal.

But the argument of Prof. Henry, on which he places his main reliance, would be untenable, even had the air been still. By the very aërial reflexion which he practically ignores, reciprocity may be destroyed in a calm atmosphere. In proof of this assertion I would refer him to a short paper on "Acoustic Reversibility," printed at the end of this volume.[1] The most remarkable case of non-reciprocity on record, and which, prior to the demonstration of the existence and power of acoustic clouds, remained an insoluble enigma, is there shown to be capable of satisfactory solution. These clouds explain perfectly the "abnormal phenomena" of Prof. Henry. Aware of their existence, the falling off and subsequent recovery of a signal-sound, as noticed by him and General Duane, is no more a mystery than the interception of the solar light by a common cloud, and its restoration after the cloud has moved or melted away.

The clew to all the difficulties and anomalies of this question is to be found in the aërial echoes, the significance of which has been overlooked by General Duane, and misinterpreted by Prof. Henry. And here a word might be said with regard to the injurious influence still exercised by authority in science. The affirmations of the highest authorities, that from clear air no sensible echo ever comes, were so distinct, that my mind for a time refused to entertain the idea. Authority caused me for weeks to depart from the truth, and to seek counsel among delusions. On the day our observations at the South Foreland began, I heard the echoes. They perplexed me. I heard them again and again, and listened to the explanations offered by some ingenious persons at the Foreland. They were an "ocean-echo:" this is the very phraseology now used by Prof. Henry. They were echoes "from the crests and slopes of the waves:" these are the words of the hypothesis which he now espouses. Through a portion of the month of May, through the whole of June, and through nearly the whole of July, 1873, I was occupied with these echoes; one of

[1] Also "Proceedings of Royal Society," vol. xxiii., p. 159, and "Proceedings of Royal Institute," vol. vii., p. 344.

the phases of thought then passed through, one of the solutions then weighed in the balance and found wanting, being identical with that which Prof. Henry now offers for acceptation.

But though it thus deflected me from the proper track, shall I say that authority in science is injurious? Not without some qualification. It is not only injurious, but deadly, when it cows the intellect into fear of questioning it. But the authority which so merits our respect as to compel us to test and overthrow all its supports, before accepting a conclusion opposed to it, is not wholly noxious. On the contrary, the disciplines it imposes may be in the highest degree salutary, though they may end, as in the present case, in the ruin of authority. The truth thus established is rendered firmer by our struggles to reach it. I groped day after day, carrying this problem of aërial echoes in my mind; to the weariness, I fear, of some of my colleagues who did not know my object. The ships and boats afloat, the "slopes and crests of the waves," the visible clouds, the cliffs, the adjacent lighthouses, the objects landward, were all in turn taken into account, and all in turn rejected.

With regard to the particular notion which now finds favor with Prof. Henry, it suggests the thought that his observations, notwithstanding their apparent variety and extent, were really limited as regards the weather. For did they, like ours, embrace weather of all kinds, it is not likely that he would have ascribed to the sea-waves an action which often reaches its maximum intensity when waves are entirely absent. I will not multiply instances, but confine myself to the definite statement, that the echoes have often manifested an astonishing strength, when the sea was of glassy smoothness. On days when the echoes were powerful, I have seen the southern cumuli mirrored in the waveless ocean, in forms almost as definite as the clouds themselves. By no possible application of the law of incidence and reflexion could the echoes from such a sea return to the shore; and, if we accept, for a moment, a statement which Prof. Henry seems to indorse, that sound-waves of great intensity, when they impinge upon a solid or liquid surface, do not obey the law of incidence and reflexion, but "roll along the surface like a cloud of smoke," it only increases the difficulty. Such a "cloud," instead of returning to the coast of England, would, in our case, have rolled toward the coast of France. Nothing that I could say in addition could strengthen the case here presented. I will only add one further remark. When the sun shines uniformly, on a smooth sea, thus producing a practically uniform distribution of the aërial currents to which the echoes are due, the direction in which the trumpet-echoes reach the shore is always that in which the axis of the instrument is pointed. At Dungeness this was proved to be the case throughout an arc of 210°—an impossible result, if the direction of reflexion were determined by that of the ocean-waves.

Rightly interpreted and followed out, these aërial echoes lead to a solution which penetrates and reconciles the phenomena from beginning to end. On this point I would stake the issue of the whole inquiry, and to this point I would, with special earnestness, direct the attention of the Lighthouse Board of Washington. Let them prolong their observations into calm weather: if their atmosphere resemble ours—which I cannot doubt—then I affirm that they will infallibly find the echoes strong on days when all thought of reflexion "from the crests and slopes of the waves" must be discarded. The echoes afford the easiest access to the core of this question, and it is for this reason that I dwell upon them thus emphatically. It requires no refined skill or profound knowledge to master the conditions of their production; and, these once mastered, the Lighthouse Board of Washington will find themselves in the real current of the phenomena, outside of which—I say it with respect—they are now vainly speculating. The acoustic deportment of the atmosphere in haze, fog, sleet, snow, rain, and hail, will be no longer a mystery: even those "abnormal phenomena" which are now referred to an imaginary cause, or reserved for future investigation, will be found to fall naturally into place, as illustrations of a principle as simple as it is universal.

While this Preface was passing through the press, the intelligence of the loss of the Schiller thrilled through the land. I look forward to a time when such a calamity upon our coast will be a simple impossibility. It is in our power to make it so; and that power will, I doubt not, be promptly and wisely employed.

ROYAL INSTITUTION, *May*, 1875.

TELEGRAPHIC DETERMINATION OF LONGITUDE.

BY F. M. GREEN,
LIEUTENANT-COMMANDER UNITED STATES NAVY.

IN the construction of new charts for the use of navigators, as well as in the correction of old ones, the assignment of different latitudes and longitudes to the same point, by various authorities, has always been a source of difficulty and embarrassment.

The exact position of all prominent points on the coasts of the United States, as well as those of England, France, and other European nations, has been determined with great accuracy; but a large portion of the earth's surface is still very imperfectly and inaccurately laid down on marine charts.

The latitude of any point being determined directly by observation, and independently of the latitude of any other place, is less likely to be in error than the longitude, which can only be ascertained with

reference to the meridian of some other place; being measured by time, is determined by the comparison of the local time with the time at some other place, the longitude of which is known.

Discrepancies in the results of observations for the determination of longitudes seem unavoidable with most of the methods usually employed, such as transportation of chronometers from place to place, observations of the relative positions of the moon and stars, and observations of occultations and eclipses.

Until the completion of telegraphic connection between this country and England, the exact longitude of the Washington Observatory was quite uncertain. A great many transfers of chronometers across the Atlantic had been effected by the Coast Survey at a great expenditure of labor and money. Yet the result of the latest expeditions differed from that deduced by Prof. Newcomb from moon-culminations by more than three and a half seconds of time, equal to nearly a mile, the final telegraphic determination lying between the two results.

In other parts of the world, however, the discrepancies are much greater. On the southern shore of the Caribbean Sea, an uncertainty of five or six miles exists with regard to many positions, and some of the islands in the Pacific Ocean have had longitudes assigned them by different surveyors within the last fifty years differing by as much as twenty-seven miles.

Where, however, chronometers have to be carried only a short distance from an established meridian, the results are much more accurate. In 1852, the longitude of Key West was measured by Coast-Survey officers from Savannah (previously established by telegraph from Washington), and was found to be 81° 48′ 30.″7. In 1873, by telegraph, Washington to Key West 81° 48′ 27.″2. It will be seen that the difference between these results is only 3.″5, equal to about 100 yards, and that the statement lately published in APPLETONS' JOURNAL, that the recent telegraphic determination showed the former position to be several miles in error, is incorrect.

Of late years the establishment of telegraphic connection between so many points of the earth's surface, both by submarine cable and by overland lines, has added to the modes of determining longitudes another, by far the most simple, elegant, and accurate.

This method can, however, only be used between places having telegraphic communication with each other; but the exact determination of these meridians renders easy the correction of errors in the longitude of neighboring places.

The establishment of differences of geographical longitude by the electric telegraph and of geographical latitudes by the zenith telescope constitute two of the most important improvements in practical astronomy of modern times, and both have had their origin in the United States. To the skillful and indefatigable astronomers of the Coast Survey and those of the corps of United States Engineers are

due the introduction and perfection of the instruments and methods now employed, which make the results so accurate and the work so simple. "Among the very earliest of the astronomers to introduce this method of measurement was the lamented Captain J. M. Gilliss, U. S. N., who determined in this way the difference of longitude between Santiago and Valparaiso, Chili."

As soon as the Atlantic cable was laid, in 1866, the Superintendent of the Coast Survey took advantage of the opportunity to establish, by way of Newfoundland and Ireland, the difference between the meridians of the British Islands and those of the United States.

In 1869–'70, a similar determination was made by different observers through the French cable from Duxbury, Massachusetts, to Brest. Again, in 1872, the measurement was made through the same cable, using the island of St. Pierre, in the Gulf of St. Lawrence, as an intermediate station.

The exquisite accuracy of the results of these measurements is demonstrated by their accordance. Referring them to the station of the New York City Hall, the resulting longitudes are as follows:

1866—west of	Greenwich	$4^h\ 56^m\ 1^s.71$	equal to	74°	0′	25″.65
1870—	" "	$4^h\ 56^m\ 1^s.70$	"	74°	0′	25″.50
1872—	" "	$4^h\ 56^m\ 1^s.67$	"	74°	0′	25″.05

The instruments in common use for making observations to ascertain the difference of longitude between two stations are, at each of the stations, a transit instrument, a break-circuit sidereal chronometer, and an electric chronograph; with the usual telegraphic sending and receiving instruments.

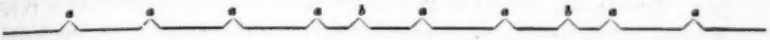
The transit instrument is a telescope, capable of being mounted accurately and firmly in an exact north-and-south line, so that the precise local time may be determined by the passage of well-known stars across the meridian.

The chronometer is adjusted to keep sidereal time and is furnished with an attachment by which the mechanism breaks an electric circuit every second.

Chronographs for the automatic registering of the exact time of any occurrence are constructed in various forms. Those generally used by astronomers in this country consist of a train of wheel-work driven by a weight, and causing a cylinder covered with a sheet of paper to make exactly one revolution in a minute.

A little carriage, to which a pen of peculiar construction is attached, moves upon wheels along the cylinder in the direction of its length, about one-tenth of an inch for each revolution of the cylinder, so that the pen records a perpetual spiral. The pen is so mounted as to have a slight lateral movement, and is so attached to an electro-magnet that, when the electric circuit in which it is placed is broken every second by the chronometer, which, with a small battery, is included in

the same circuit, the mark made on the chronograph-paper, instead of being a straight line, will be broken at regular intervals as shown at *a*.



By means of a little instrument called a break-circuit key, in the hands of the observer, and included in the same circuit, the electric current may be interrupted, causing the pen to make a similar mark as shown at *b*, on the occurrence of any event, such as the passage of a star across the wires of the telescope.

With a finely-divided scale the position of this arbitrary mark, with reference to the nearest second mark, may be accurately established, and the exact time accurately ascertained to within $\frac{1}{10}$ of a second.

By means of these instruments, the error of the chronometer is found at each station with great accuracy, and, the times shown by the faces of the chronometers being compared by telegraph, the difference of time and corresponding difference of longitude are readily deduced.

The time occupied by an electric impulse to traverse the wire from one station to another, and act upon the telegraph-instruments, though generally very small, is too great to be neglected, but is easily ascertained and allowed for.

Suppose *a* to be a station, one degree of longitude east of another station *b*, and that at each station there is a clock exactly regulated to the time of its own place, in which case the clock at *a* will be, of course, four minutes faster than the clock at *b*. Let us also suppose that a signal takes a quarter of a second to pass over the telegraph-wire connecting the two stations.

Then if the observer at *a* sends a signal at exactly noon, by his clock, to *b*	12ʰ	0ᵐ	0ˢ
It will be received at *b* at	11ʰ	56ᵐ	0ˢ.25
Showing apparently a difference of time of		3ᵐ	59ˢ.75
Then if the observer at *b* sends a signal at noon by his clock	12ʰ	0ᵐ	0ˢ
It will be received at *a* at	12ʰ	4ᵐ	0ˢ.25
Showing an apparent difference of time of		4ᵐ	0ˢ.25

One-half the sum of these differences is 4 , which is exactly the difference of time and of longitude; and one-half of their difference is 0ˢ.25, which is exactly the time taken by the electric impulse to traverse the wire and telegraph instruments. This is technically called the "wave and armature time."

The error of each chronometer being ascertained by observations of stars at each station, and the difference of the chronometers being in this way shown by the exchange of signals, the difference of the local times, which is the difference of longitude of the two stations, is easily deduced.

Some English astronomers have objected that, where the line is, as

is usual in long land-lines, divided into lengths connected by telegraphic repeaters, the time of transmission will not be the same in both directions, and that the same effect would be produced in a submarine cable having an imperfection or leak nearer one end than the other. Experiments, however, by the Coast Survey on the long line from Washington to San Francisco indicate that this objection, though theoretically true, is of no practical importance.

Upon land-lines the time-signals sent can be recorded directly on the chronograph by putting it in the telegraphic circuit; but, with submarine cables, the electric impulse transmitted is not strong enough to act upon the electro-magnets of the chronograph-pen.

For telegraphing with weak impulses over submarine lines a very beautiful device was invented by Sir William Thomson, and is now in general use.

To a delicately suspended magnet, surrrounded by a coil of fine covered wire, a small mirror is attached. From this mirror a beam of light from a lamp is reflected on a scale in a dark room. When no currents are being sent over the line, this beam remains at rest; but, when, at the sending station, either of two keys is pressed, a positive or negative current, as the case may be, is sent through the cable, and through the coil surrounding the magnet, causing the magnet with its mirror to turn and to deflect the ray of light to the right or left.

When the signal arrives and is perceived, the observer touches his chronograph-key, thus recording the time of its arrival.

The completion of the West India and Panama Telegraph Company's cable in 1873, and the certainty that serious errors existed in the geographical positions of many places in the West Indies and South America, caused Commodore R. H. Wyman, U. S. N., Hydrographer to the Navy Department, to turn his attention to the outfit of an expedition which should seek to determine with all possible accuracy the latitudes and longitudes of points connected by telegraph in that part of the world.

The authority of the Navy Department was readily obtained, and the necessary preparations were commenced in the spring of 1873.

In order that the work might be accomplished with economy, as small a vessel as possible was desirable, the Fortune, a strong iron tug-boat of 300 tons, being selected and prepared. Although this little vessel carried the officers and men of the expedition safely, she was found to be too small to encounter heavy weather at sea with any degree of comfort.

The astronomical outfit was superintended by Mr. J. A. Rogers, of the Hydrographic Office, and was in all respects satisfactory.

The telescopes used were constructed at the repair-shop of the Hydrographic Office for the purpose, and were a combination of the transit instrument with the zenith telescope, a modification working admirably in practice, and first suggested by Prof. C. S. Lyman, of

Yale College. These instruments were so constructed that the eye-piece was at one end of the horizontal axis, a prism at the junction of the axis and telescope-tube reflecting at a right angle the rays from the object-glass, thereby enabling the observer to direct the instrument upon stars of any elevation above the horizon without change of position.

The command of the expedition was given to Lieutenant-Commander F. M. Green, U. S. N., and it was intended that the work should be commenced in the winter of 1873–'74; but the non-completion of the instruments and the probability of trouble resulting from the Cuban outrages interfered with this plan, and the Fortune was temporarily employed as a tender to the squadron at Key West.

Upon the dispersion of the assembled squadron in April, 1874, Lieutenant-Commander Green was directed to complete a survey of the Mexican Gulf coast, commenced by the United States steamship Wyoming. This work employed the time till the following August, when the Fortune returned to Washington, and was at once refitted for the prosecution of the original design.

Fortunately for the success of the work, the services of Mr. Miles Rock, formerly of the observatory at Cordova, were secured as principal astronomical assistant; and the Fortune sailed on the 24th of November, 1874, from Hampton Roads for Jamaica.

Upon arrival at Kingston, definite arrangements were made with the manager of the telegraph cables, the gratuitous use of which had been offered very promptly and courteously by the London board of directors.

As it had been decided to commence the work by measuring between Panama and Aspinwall, the Fortune sailed for the latter place on the 9th of December, arriving on the 12th.

Portable observatories had been constructed, to shelter the instruments and observers, and were immediately set up at Panama and Aspinwall upon obtaining permission from the local authorities.

Throughout the work the same general system was pursued, and was briefly as follows: As soon as practicable after the establishment of a party at each station, the work was commenced by observing stars on five clear nights, from 8 to 10 P. M., and from 11 P. M. to 1 A. M. for determining the errors of the chronometers, and during the hour from 10 till 11 P. M. exchanging time-signals between the two stations. This was effected as follows:

Telegraphic communication being established between the observatories, the senior observer sent a preparatory signal at ten seconds before the completion of a minute by tapping his key several times in quick succession; then exactly at the even minute, pressing his key again for about a quarter of a second, and repeating this signal at intervals of five seconds till the completion of the next even minute. The hour and minute when the first signal was sent were then tele-

graphed to the receiving station and repeated to insure correctness. The time of arrival of these signals was recorded by the chronograph at the receiving stations, and five similar sets were exchanged in each direction, making sixty-five comparisons each way.

After five nights of this work, zenith telescope observations of pairs of stars were made on four nights for latitude.

In this way, during the winter, the stations of Panama, Aspinwall, Kingston, Santiago de Cuba, and Havana, were occupied, the exact difference of time between each station and the next and the latitude of each being ascertained. It was intended to continue the work to Key West, thus connecting with a Coast Survey station, but the occurrence of yellow fever among the crew of the Fortune, and the breaking out of that disease at Key West, caused the postponement of this measurement till the next season.

By combining these ascertained differences of time, and applying the result to a determined position, the longitude of each place will be decided with a very small limit of error.

In addition to the above observations, the exact habitual error of observing, or relative personal equation of the two observers, must be ascertained and applied to the result.[1]

The method of star-signals, or the comparison of the times at which the same star passes over the meridians of two stations, is seldom used now, and therefore is not described in detail.

The authorities of each country visited extended the most gratifying courtesy and assistance to the officers of the expedition. Especially was this the case in the island of Cuba, where a Spanish naval officer was detailed to assist in the work.

On the 5th of April last, all work practicable during this season being finished, the Fortune left Havana, completing her cruise by arriving at the Washington Navy-Yard on the 12th of the same month.

The computation of the numerous observations made during the past winter is now being prepared, and, as soon as completed, the results will be published.

Some improvements and modifications, which the experience of the past year has suggested, will be made in the instruments and outfit, and the same officers in a larger and more commodious vessel will leave the United States during the coming autumn, to continue the measurements through the Virgin and Windward Islands to the coast of South America.

Although the naval surveyors of nearly all maritime nations (particularly the English) are constantly at work perfecting the knowledge of the earth's surface, it is believed that this is the first systematic naval expedition for establishing by this method secondary meridians to which other positions may be referred.

In connection with their preparations for observing the recent

[1] *See* POPULAR SCIENCE MONTHLY, vol. vi., p. 385.

transit of Venus, German astronomers have made some telegraphic measurements of differences of time in the East Indies; but the vast and constantly increasing net-work of cables nearly surrounding the earth will afford work for years to come, and will, in a way hardly contemplated by the projectors, add in a very great degree to accurate geographical knowledge.

THE AMERICAN CHIPMUNK.

By CHARLES C. ABBOTT, M. D.

WITH the first sweet blossoms of the Epigæa, and long before the foremost warbler greets his old-time home with gleesome songs, our little chipmunk has roused himself from his long winter's nap, and, sniffing the south wind, as it whirls the dead leaves about, scampers to and fro while the sun shines, and dives into his winter-quarters, it may be for a whole week, if the north wind whispers to the tall beech-trees. But the blustering days of March give way in due time to showery April, and then, with more courage, "chip" faces the music of the winds, blow they from whatever quarter, and darting along the top rail of our zigzag fences, chatters, scolds, and calls at and to his equally noisy companions. They know full well that they have the summer before them, and, while determined to enjoy it, begin early and in good earnest to make arrangements for its coming duties. We watched several pairs of them from March to November, during the last year (1874), and our sketch is based on numerous notes made at different times.

Until the weather became fairly settled, and really spring-like in temperature, these little chipmunks did not frequently show themselves, and then only in the middle of the day. The occurrence of a cold storm they appeared to foretell by twenty-four hours, and resumed their hibernating sleep, becoming lethargic, and very difficult to restore to consciousness. A pair that we dug out in March, having two days before reëntered their winter-quarters and become again torpid, were apparently lifeless when first taken up in the hands, and not until after several hours' warming did they become lively and altogether themselves again. This seemed to us the more curious, in that they can respond to a favorable change in the weather in a short time, even when the thermometric change is really but a few degrees.

On the 3d of May a pair made their appearance in the yard of our residence, and took up their abode in a stone-wall having a southern outlook, and on the edge of a steep descent of seventy feet; which hill-side is thickly wooded, and harbors scores of these little chip-

munks, or "ground-squirrels," as they are more commonly called. From the fact of these little animals living wholly underground, and it being stated that their underground homes were quite elaborate in structure, we determined to wait until the pair in our yard had completed their excavations in and under the stone-wall, and arranged

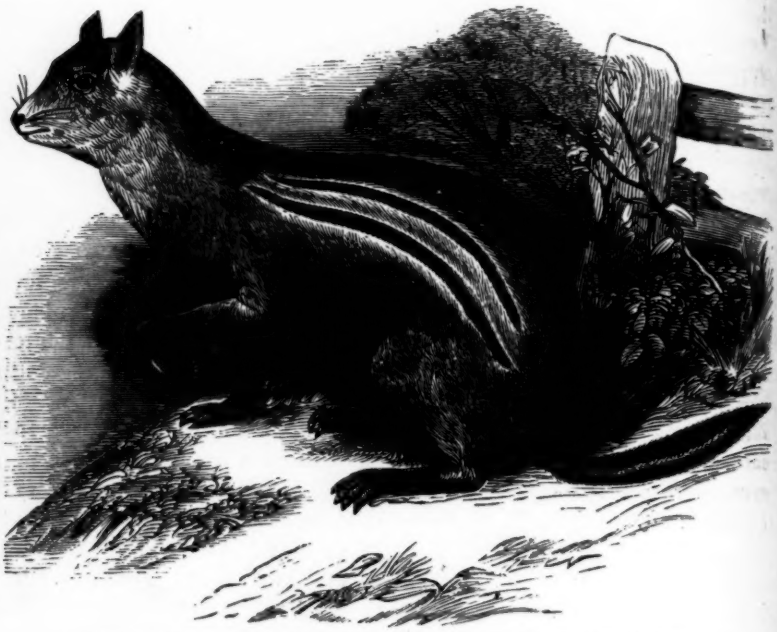


FIG. 1.—AMERICAN "CHIPMUNK" (*Tamias Lysteri*), HALF NATURAL SIZE.

their nest, which time we judged by their actions, and then seeking out the home of another couple, which was readily accessible, we undertook to expose the nest and its approaches. This we did on May 29th. The general character of the nest and its approaches are seen in the sketch. The nest contained five young, not more than forty-eight hours old. The two entrances were at the foot of a large beech-tree standing about six feet from the brow of the hill. The grass alone grew about the tree, and the holes on the surface of the ground were very conspicuous. No attempt at concealment had been made; but this was evidently because there is here almost a total absence of their particular enemies. Animals soon learn this fact, and their homes and habits vary with the knowledge. From the right-hand entrance to the nest was an intervening space of nine feet traversed by a cylindrical passage somewhat serpentine in its course, which made the distance really about twelve feet. The nest itself was oval, about twenty inches in length (the cut makes it appear too large), and ten inches in height. It was lined with very fine grass. We

had hoped to find several passages leading from the nest, and two or more "extra" nests, or magazines for storing away food, but no trace of them was to be found.

On the 23d of June, six young chipmunks made their appearance about the stone-wall in the yard, and to these, with their parents, we will now confine our attention. It puzzles us now when we think of it, to imagine when this company of eight chipmunks took any rest. Very frequently during the summer we were astir at sunrise, but the chipmunks were already on the go, and throughout July they appeared to do little but play; which sporting, by-the-way, is very animated. They seem to be playing at what children know as "tag," i. e., they chase each other to and fro, and try not simply to touch, we should judge, but to bite each other's tail. The way in which they scamper along the tapering points of a paling fence is simply astonishing; but however mad may be their galloping, let a hawk come near, and in a moment every one is motionless. If on a fence, they simply squat wherever they may be at the time, and trust to remaining unnoticed. If on the ground, and not too far from their burrows, which is not often the case, they will dart to their nests with an incredible celerity, going, we believe, the whole length of their passage-way to the nest, turning about, and retracing their steps to the entrance, from which they will peer out, and, when the danger is over, reappear and recommence their sports. These little animals

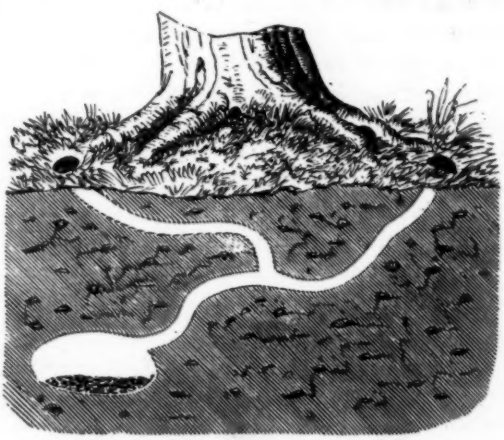


FIG. 2.—NEST OF "AMERICAN CHIPMUNK."

play merely for play's sake, and have no more important object in view than amusement. Indeed, so far as we have studied animal life, this indulgence in play, just as children play, and for the same reasons, is common to all animals. We have often seen most animated movements on the part of fishes that could be referred only to play.

That some work was accomplished during July by our eight chip-

munks, we have no doubt, as early in August we dug out a nest beneath an oak, on the hill side, and we found, besides the nest proper, two nest-like cavities, and in one of which—that most distant from the nest—was about a quart of yellow corn (maize). We judge, therefore, that these "magazines" were dug out by the chipmunks late in the summer, and similar ones, no doubt, were excavated by the chipmunks in the stone-wall. What they did with the dirt we cannot guess. Certainly not a particle of it could be found about their nests' entrances.

About August 15th they commenced to work in real earnest. Instead of playful, careless creatures, that lived from hand to mouth, they became very sober and busy indeed. Instead of keeping comparatively near home, they wandered to quite a distance, for them, and, filling both cheek-pouches full of corn, chincapins (dwarf chestnuts), and small acorns, home they would hurry, looking, in the face, like children with the mumps. This storing away of food was continued until the first heavy white frosts, when the chipmunks, as a member of Congress once said, went "into a state of retiracy."

The food gathered, we believe, is consumed in part, on their going into winter-quarters, they spending some time in their retreats before commencing their hibernating sleep. This belief, on our part, is based on the result of digging out a third nest on the 3d of November. The last time we noted down seeing a chipmunk belonging to a certain nest was October 22d. Twelve days after we very carefully closed the three passages that led to the nest, and dug down. We found four chipmunks very cozily fixed for winter, in a roomy nest, and all of them thoroughly wide awake. Their store of provisions was wholly chestnuts and acorns, and the shells of these nuts were all pushed into one of the passages, so that there should be no litter mingled with the soft hay that lined the nest. How long this underground life lasts, before hibernation really commences, it is difficult to determine; but as this torpid state does not continue until their food-supply is again obtainable out-of-doors, the chipmunks, no doubt, store away sufficient for their needs throughout the early spring, and perhaps until berries are ripe.

So much for the present year, now nearly passed away; but we are not done with the chipmunks yet, and next year, if all goes well, we purpose to follow the wanderings of the young brood of the past summer, for, we suppose, the old couple will not want them after spring once fairly comes again this way.—*Science-Gossip.*

THE ENDOWMENT OF SCIENTIFIC RESEARCH.

By RICHARD A. PROCTOR.

II.

THE public endowment of science presents itself as a desirable supplement to the various means of maintenance considered in the previous part of this article. Those departments of science, in particular, which require costly instruments, which can only be pursued with the aid of trained assistants, or which, in other ways, involve greater expense than a man of ordinary means can afford, seem to require and deserve assistance from the national purse. On abstract principles, this use of the nation's wealth is strongly to be recommended. The subject is altogether worthy; the expenses would not be great, compared with others which are readily borne for purposes far less worthy; and this manner of supporting science commends itself to the respectful consideration of a nation accustomed, in spite of repeated disappointments, to regard state control as a surer resource than private efforts. I think every zealous student of science, to whom the subject might be submitted, would be apt, at a first view, to decide unhesitatingly that the endowment of science could not but be fruitful in good results.

So soon, however, as details are considered, and especially when candidates for the nation's money come forward and tell us precisely what they want, the matter assumes a different aspect.

So far as the source whence money could be provided for the endowment of science is concerned, there is little difficulty. The additional taxation required to meet all probable expenses would be so light as scarcely to be appreciable. But in truth a fund already exists out of which the cost of the endowment of science might be defrayed either wholly or in great part—the sums bequeathed in old times to the universities. Nor would this application of university property involve a departure from the purpose for which those sums were originally bequeathed. On the contrary, we have evidence to show that the universities were originally founded, not for educational purposes solely or chiefly, but for the advancement and preservation of knowledge. In the third report of the Commissioners for the Advancement of Science, we find that the witnesses examined were "on no point more united than in the expression of the feeling that it is a primary duty of the universities to assist in the advancement of learning and science, and not to be content with the position of merely educational bodies;" and the evidence quoted shows that this opinion was based on the fact that such was the original purpose of the universities—that, in fact, "the collegiate foundations of the universities were originally and fundamentally, although not absolutely and entirely, destined for"

that object. "This object" proceeds the report, "is certainly not less important in modern than [it was] in ancient society. In the middle ages, knowledge would altogether have perished if it had not been for such foundations, and it appears that now, from other causes, the pursuit of knowledge and of general scientific investigation is subject to very real dangers, though of another kind than those which then prevailed, and which make it very desirable to preserve any institution through which scientific discovery and the investigation of truth may be promoted."

Granting, however, first the desirability of endowment for science on abstract principles, and secondly that the necessary funds either already exist, or can be easily raised, we find ourselves in presence of the practical difficulties involved in the distribution of such funds. Decision must be made: first, as to the scientific subjects which shall be selected for endowment; secondly, as to the persons under whose supervision the funds for this purpose should be distributed; and thirdly, as to the persons to whom these funds should be dispensed.

On the first point, it is to be noticed that, since, for a long time, the administration of endowment would chiefly rest with non-scientific persons, the question of the practical value of different scientific subjects would at first be of primary importance. It is not to be expected that the value which scientific researches possess, apart from all material benefits they may bring with them, should be generally recognized. A principle of selection would have to be adopted at first which men of science would regard as essentially unsound. Nevertheless, little direct mischief would follow from this circumstance, though many advantages would for a time be lost. The limitation would exclude subjects worthy of the highest consideration: but these are already excluded; and many subjects now receiving no public support would be admitted. I apprehend that the most unfortunate result of this state of things would flow from the fact that persons desirous of securing money grants for a scientific subject of the non-productive sort might be tempted, rather than allow the nation to neglect it, to *imagine* material advantages from its cultivation. I am not aware that many instances exist whereby to illustrate this point, or indeed that as yet any appeal has been made for special endowment save in a single instance. But this instance chances to illustrate my meaning exceedingly well.

It will probably be admitted that the practically useful applications of astronomy are at least as well provided for by the nation as those of any other branch of science, not excluding chemistry or pure physics. Occasionally, also, government has provided, not without generosity, for astronomical researches little likely to lead to results of practical utility. Recent eclipse expeditions, and still more the expeditions for observing the late transit, are instances in point, seeing that it is almost impossible to conceive that mankind can derive any

direct benefits from a knowledge of the sun's surroundings, or of the distance, size, and mass of that luminary. But the nation makes no direct provision for researches into the physical condition and nature of the sun, the planets, stars, star-cloudlets, comets, the moon, and so on. Nor, probably, would an appeal for new observatories to meet this want receive general or effectual support at present. But, about three years ago, it was thought advisable, by two or three persons, to bring a scheme of this nature before the Astronomical Society, so as to secure the support of that body in submitting the matter to those in charge of the national purse. Of the fate of this scheme with the Astronomical Society I need say nothing, save that the Council were practically unanimous in rejecting it—only four voting in its favor. But I would direct particular attention to the nature of the argument used to obtain support for this scheme: "Permanent national provision," said its advocate, "is urgently needed for the cultivation of the physics of astronomy. If the study of the sun alone were in question, that alone would justify such a measure; for there can hardly be a doubt that almost every natural phenomenon connected with climate can be distinctly traced to the sun as the great dominating force, and the inference is unavoidable that the changes, and what we now call the uncertainties of climate, are connected with the constant fluctuations which we know to be perpetually occurring in the sun itself. The bearing of climatic changes on a vast array of problems connected with navigation, agriculture, and health, need but to be mentioned to show the importance of seeking, in the sun, where they doubtless reside, for the causes which govern these changes. It is, indeed, my conviction, that of all the fields now open for scientific cultivation, there is not one which, quite apart from its transcendent philosophical interest, promises results of such high utilitarian value as the exhaustive systematic study of the sun."[1]

[1] I quote from a paper by Lieutenant-Colonel Strange, a Fellow of the Astronomical Society. Of course this would not be the place to discuss his remarks. It need hardly be said that no astronomer has ever sanctioned such views, though many astronomers believe that an association exists between terrestrial relations and the phenomena of solar disturbance. It may suffice to remark here that the influence of changes in the sun's condition, as manifested by sun-spots and other solar peculiarities, must be infinitely less than the influence of those changes of aspect which produce the seasons; and yet our acquaintance with *these* changes leaves the "uncertainties of climate" still unexplained. How much less must be the significance of the cycles of changes in the solar spots! The chief of *these*, again, are already known, yet we are as far as ever from being able to predict the weather. Even the theories which have been advanced as to the connection between rainfall, prevalent winds, etc., and the spot-cycle, compel their advocates to assume contrary influences for different regions separated by nodal lines of no influence, which lines must also be assumed to shift their position from year to year—theoretical devices admitting of being most conveniently adapted to circumstances which would be fatal to any definite theory. Sir J. Herschel well remarks of such ideas that though "some rude approach to the perception of a cycle of the seasons may possibly be attainable, no person in his senses would alter his plans of conduct for six months in advance in the most

It would be fatal to scientific interests if such a mistake as this were often repeated. Yet we can have no assurance that the Government would not again and again be invited to support science on the strength of unfounded promises, if any wide scheme of endowment were adopted whose administration should be intrusted to non-scientific persons.

If the administration of the funds for scientific endowment were from the beginning intrusted to leading men of science, it is probable that correct scientific principles would be adopted for their guidance. But then a difficulty would arise which might prove even more serious than the mistakes of the unscientific. No one acquainted with the history or present condition of science, and with the relations which have existed and continue to exist among science-workers, can doubt that scientific managers of endowment funds would be repeatedly called upon to decide on the claims of methods or subjects to which they had conceived objections, and to vote respecting the candidature of scientific men against whom they entertained feelings of personal hostility. The first case can be illustrated by example, the other not so conveniently. Suppose Leverrier had been called upon to determine whether any sum from an endowment fund should be given prospectively for researches into the subject of transits of Venus, we may be sure (his actual course in the matter leaves no room for doubt) that his prepossession in favor of that method of measuring the solar system which is based upon the planetary perturbations would have led him to decide against any such grant. Many cases akin to this will occur to those familiar with recent controversies in various branches of scientific research. As to personal animosities, we may follow the convenient example of those writers who trace the faults of persons in high places down to a certain date, and leave the present time to the criticisms of future historians. It will be admitted that both Halley and Flamsteed were faithful servants of science; yet if either had had to decide on any question of awarding to the other some post of influence or emolument, it is to be feared, from what we know of their actual conduct toward each other, that the result would not have depended solely on scientific considerations. It may be hoped that there has been a change for the better since then, and that matters will improve still more hereafter. The advocates of rival theories, the leading teachers of different schools of thought, will one day, perhaps, be constantly on good terms with each other. Dissensions will be unknown in our scientific societies. The older men of science will be well pleased to see younger workers gradually modifying theories which had formerly seemed established forever, and the younger workers will never give unpleasant expression to the feeling that "authority" is not an absolutely certain guide in science. Jealousies and rivalries among those working in the same departments will gradually become

trifling particular on the faith of any special prediction of a warm or a cold, a wet or a dry, a calm or a stormy summer or winter."

things of the past. At present, all we can say is, that matters are improving at such a rate that . . . that they may be allowed, without disadvantage, to improve a little longer. If men of science were suddenly called upon to administer any extensive scheme of public endowment for science, this improvement might be checked, which would be unfortunate.

As regards the class of men who would come forward if science were endowed, much would doubtless depend on the position offered to the candidates for office, and on the qualifications demanded. In these days of competitive examinations, it seems probable that careful preliminary inquiry would be made into the proficiency of the candidates, at least in departments of learning associated with their special science. Again, it may be presumed that every office under the new system would have definite duties attached to it, even though matters were so arranged that ample time would be left for original research. It ought certainly to be arranged, moreover, that from time to time every holder of a salaried office should be called upon to give satisfactory proof that he was not wasting his own time and the nation's money. It would be unpleasant if a large salary were assigned for life to a zealous student of science, and then, by some accident, his zeal diminished. The mere loss of so much money annually would be of little importance to the nation; but the discredit to science would be a very serious matter. Unfortunately, those who ought to know assert that among the persons who seem most earnest in the cause of science, and who not only seem, but *are* exceedingly earnest in advocating the endowment of science, there are not wanting men who may be characterized as "scientific Micawbers, waiting for something to turn up." They may be recognized by men of discernment, because of their tendency to dilate upon their own work, to take credit for the work or methods of others, and to urge (anticipating, perhaps, the endowment of science) that large salaries should be given for the discharge of exceedingly indefinite duties. In any wide scheme for the endowment of research these persons would have to be carefully watched. The money wasted on them would be a matter of very little moment; but science would be degraded in the eyes of the world, and mischief, not easily reparable, would be wrought, if such men as these worked their way into the best-paid offices.

It may, perhaps, be urged that a system of payment by results might be established. Mr. Mattieu Williams, the ingenious author of "The Fuel of the Sun," in a letter commenting upon a leading article (mine, as it chanced) in the *Chemical News* for September 5, 1873, advances this as the only sound and natural principle of public endowment for science. The case seems very simple as he presents it: "If a fund for the payment of scientific research existed," he says, "the genuine worker might send in his bill with the paper communicating the results of his researches, and such a bill, after being fairly

taxed, should be paid like any other honest account, in a simple and business-like manner. The toiler in the workshop of science who reveals a new truth is a benefactor to the whole of mankind, has a fair and honest claim against the whole human race, and is entitled to draw a bill accordingly, which should be accepted and honored by his own country at least. Decent gratitude and common honesty demand so much from the nation. It should be done, and may be done, without opening a door to jobbery or any multiplication of corrupt and idle pensioners." I fear that though this might, perhaps, be managed in Utopia or the New Atlantis, it could scarcely be effected in England or any other country at present existing. The accounts that would be handed in to the minister of science under any such system would present a strange medley of real and false discoveries. His time would be chiefly occupied in objecting to undue estimates of results, and in endeavoring (hopelessly) to settle rival claims of contending discoverers. Besides, it is absolutely impossible to devise any scale of valuation for scientific discoveries. Conceive the state of mind of the minister of science, who, after disposing of claims for the quadrature of the circle, the discovery of perpetual motion, new cosmogonies, schemes of weather prediction, and the like, should suddenly find himself called upon to decide the money value of some great achievement in science, such as Newton's discovery of universal gravitation, or Kirchhoff's interpretation of the solar spectrum.

Whether the intrinsic value of any result, or the time and labor it had cost, were considered, the difficulty of determining how much should be paid for it would be alike insuperable. If the former were the test, who should determine the intrinsic value? The discoverer might perhaps overrate it, or, if he were really an earnest student of science, he would either underrate it, or be unwilling to make any claim at all. Others would, for the most part, be unable to estimate the result at its true worth, if it were really a discovery of importance. For the discoverer must commonly be in advance of his fellow-workers in the department of research to which his discovery belongs. He alone knows the relation of his discovery to work already accomplished in the same direction. Let any specialist, who has just obtained some notable result, be asked to name half a dozen experts in his own subject to whose opinion he would be willing to submit his discovery, and it will be found that he will with difficulty name half as many, and those not specially eminent in that subject.

As to the amount of time and labor devoted to any subject of scientific research, it is tolerably certain that the nation would object to any system of retrospective endowment based on that criterion. The ardent student of science gives many more hours of his time to his favorite subject of research than any government would be willing to pay for, at the present day, or for many years to come.

Past experience, not in scientific matters alone or chiefly, but gen-

erally wherever state maintenance has been provided for work which before had been carried on independently of the government, suggests that the wisest course would be to proceed tentatively. It is almost certain that any general scheme formed at the present time would hereafter have to be greatly modified, if not altogether abandoned. The time, indeed, has not yet arrived when the nation would look with satisfaction on any wide scheme of scientific endowment, even if Parliament could be persuaded to make adequate grants for such a scheme, or to authorize the employment for that purpose of funds available at the two universities. As to the action of our legislators, it may be remarked that possibly a favorable vote might be secured, if the more earnest supporters of endowment (who have shown considerable strategic skill in pushing their schemes) should choose a convenient season and convenient hours for bringing the matter before Parliament. But it is to be hoped that science will not be degraded by a line of action implying that the endowment of science requires to be urged as cautiously in Parliament as an act relating to contagious diseases. The most liberal grant would be dearly purchased by the disgrace which such a proceeding would bring upon science.

The nation is probably willing to see experiments made on the effect of endowment for special scientific purposes. If such experiments were made, we should gradually perceive whether wider schemes were likely to be advantageous to science, or whether dangers may not lurk in all such schemes. It might be found that endowment would tend greatly to increase the number of those entering on scientific pursuits, while widening also the range of scientific culture. It might be found, as some assert, that endowment would give the younger men a better chance of making good progress than they at present possess. Or, on the other hand, it might be found that the national endowment of science would tend only to advance scientific Micawberism, and that the real workers in science would be discouraged by seeing all the best rewards given for pretentious novelties, clever adaptations perhaps of their own discoveries. That, too, which Herbert Spencer has described as "the rule of all services, civil, military, naval, or other," might be found to operate with the scientific service also—the rule, namely, of "putting young officials under old," with its necessary "effect of placing the advanced ideas and wider knowledge of a new generation under control of the ignorance and bigotry of a generation to which change has become repugnant." This, "which is a seemingly ineradicable vice of public organizations, is a vice to which private organizations are far less liable; since, in the life-and-death struggle of competition, merit, even if young, takes the place of demerit, even if old."

It appears to me that those who really desire the advancement of science cannot too carefully or cautiously weigh the schemes now rife

for the endowment of physical research. Unquestionably, the abstract proposition that science is worthy of national support must be admitted as just. We may agree with Sir John Herschel in feeling "prepared to advocate or defend" (on abstract principles) "a very large and liberal devotion indeed of the public means to setting on foot undertakings and maintaining establishments in which the investigation of physical laws and data should be the avowed and primary object, and practical application the secondary, incidental, and collateral one." It is hardly necessary for me to say that I recognize the full weight of those considerations which have been urged in favor of wide schemes of endowment. Such schemes have, indeed, had few warmer advocates than myself, nor has any one been more outspoken in their support. But practical experience has taught me, I must confess, that dangers—and serious ones—surround them. Even while as yet they were in their infancy, mischievous tendencies began to show themselves which had certainly not been anticipated by those earnest students of science who first supported the general principle that science deserves the recognition of the state. Greedy hands were stretched out for the promised prizes. Jobbery began its accustomed work; and those who sought to check its progress were abused and vilified. If this happened when schemes for endowment were but mentioned, what evil consequences might not be looked for if those schemes succeeded? Deterred by the consequences of the first few steps they had taken in the direction of endowment, many of the most zealous workers in science now stand aloof. Before long, however, the real position of affairs will be known. If the present desire for the endowment of research is prompted by genuine zeal for science, we shall find that the warmest advocates of the scheme are not those who would themselves profit by it. But if, on the other hand, it should appear that the persons who now speak most earnestly about the endowment of science are in reality eager chiefly for their own preferment, or desire to secure posts of emolument for personal friends and adherents, then every real lover of science must desire the failure of such schemes, seeing that the cause of science could not fail to suffer, nor Science herself to be degraded, should they prove successful.—*Contemporary Review.*

THE PYROPHONE.

By M. DUNANT.

SOUND is in general, according to natural philosophers, a sensation excited in the organ of hearing by the vibratory movement of ponderable matter, while this movement can be transmitted to the ear by means of an intermediate agent. Sound, properly called musi-

cal sound or tone, is that which produces a continuous sensation, and of which one can appreciate the musical value. Noise is a sound of too short a duration to be appreciated well, as the noise of a cannon, or else it is a mixture of confused and discordant sounds like the rolling of thunder. For a single sound to become a musical sound, that is to say, a tone corresponding to one of the intonations of the musical scale, it is necessary that the impulse and, consequently, the undulations of the air should be exactly similar in duration and intensity, and that they should return after equal intervals of time. In its change to the musical state, however dull and confused the noise may be, it becomes clear and brilliant. Like the diamond, after having been polished and cut according to the rules of art, it has the brilliancy for the ear which the former has for the eye. This is what takes place in singing-flames. Very imperfect in its beginning, hoarse, roaring, or detonating, it does not come nearer the musical sound, properly so called in the chemical *harmonica*, as it is termed, still, by means of reiterated trials, the sound of the single flame in the tube, the *lumen philosophicum*, as it is elsewhere called, can it be musically produced in every case.

It has long been known that a flame traversing a glass tube under a certain pressure produces a musical sound. The eminent *savant*, Prof. Tyndall, to whom the greater part of the deep questions in physics are no mysteries, has studied singing-flames, but it must be admitted that singing-flames have only penetrated into the dominion of art in consequence of the discovery made by M. Frederick Kastner of the principle which allows of their being tuned and made to produce at will all the notes of the musical scale, to stop the sound instantaneously and mechanically; as in keyed instruments, the sound is regulated and subdued as desired. It is thus that the modest *harmonica chimique*, *lumen philosophicum* of natural philosophers has, in the pyrophone, attained to the character of a real musical instrument; this happy result supports the remark that the observation in Nature of the phenomenon of sound may conduct man, if not exactly to the invention of music, at least to endow the art with resources which increase its power. The sound of the pyrophone may truly be said to resemble the sound of a human voice, and the sound of the Æolian harp; at the same time sweet, powerful, full of taste, and brilliant; with much roundness, accuracy, and fullness; like a human and impassioned whisper, as an echo of the inward vibrations of the soul, something mysterious and indefinable; besides, in general, possessing a character of melancholy, which seems characteristic of all natural harmonies. The father of this young philosopher, a member of L'Institut de France, and a learned author, who died in 1867, treating on cosmic harmonies, insists on this peculiarity:

"The harmonies of Nature," said he, "which, in their terrible grandeur as well as in their ineffable sadness, have ever charmed the philosopher, poet, and

artist, are most often stamped with a character of vague melancholy, from the influence of which the mind cannot escape. It is especially when the noise of the world is hushed that these powerful harmonies produce the most overpowering and poetical effects."

It characterizes, for example, the sound of the echo, the sound called harmonics, and many others which are included in the range of musical tones, defined further on under the name of *chemical and sympathetic music.* We have the most remarkable examples of these in the sound of the Æolian harp. Science, as well as philosophy, poetry, and musical art, is interested in the further study of these sounds. In Germany, Goethe and Novalis, in France, Jean Paul, and many others, have eagerly appreciated the bond which unites natural harmonies to the most elevated instincts, and to the most ideal aspirations of the human soul.

Prof. Tyndall has recognized the fact that, in order to render a flame musical, it is necessary that its volume be such that it should explode in unison with the undulations of the fundamental note of the tube, or of one of its harmonics. He also asserts that, when the volume of the flame is too great, no sound is produced; he demonstrates it, by increasing the flow of gas. Prof. Tyndall has also called attention to this fact, that, in order that a flame may sing with its maximum of intensity, it is necessary that it should occupy a certain position in the tube. He shows this by varying the length of the tube over the flame, but he does not specify the proportions which must exist between the flame and the tube for obtaining this maximum intensity of sound. M. Kastner's merit is in having shown that, when two or several flames are introduced in a tube, they vibrate in unison, and produce the musical maximum of sound when they are placed one-third the length of the tube, and, if these two flames are brought in contact, all sound ceases directly, a phenomenon M. Kastner demonstrates to be caused by the *interference of sounding flames.* Here is a question, lately scarcely thought of, of which M. Frederick Kastner has determined the laws, at the same time making a most remarkable application of them in creating an instrument which reminds one of, and may be mistaken for, the sound of the human voice.

A very simple mechanism causes each key to communicate with the supply-pipes of the flames in the glass tubes. On pressing the keys the flames separate, and the sound is produced (Fig. 1). As soon as the fingers are removed from the keys the flames join, and the sound ceases immediately (Fig. 2). These new experiments made by M. Kastner upon singing-flames should cause all makers of musical instruments to turn their attention to inventions connected with sound. If two flames of suitable size be introduced into a glass tube, and if they be so disposed that they reach one-third of the tube's height, measured from the base, the flames will vibrate in unison. This phenomenon continues as long as the flames remain apart, but the sound ceases as

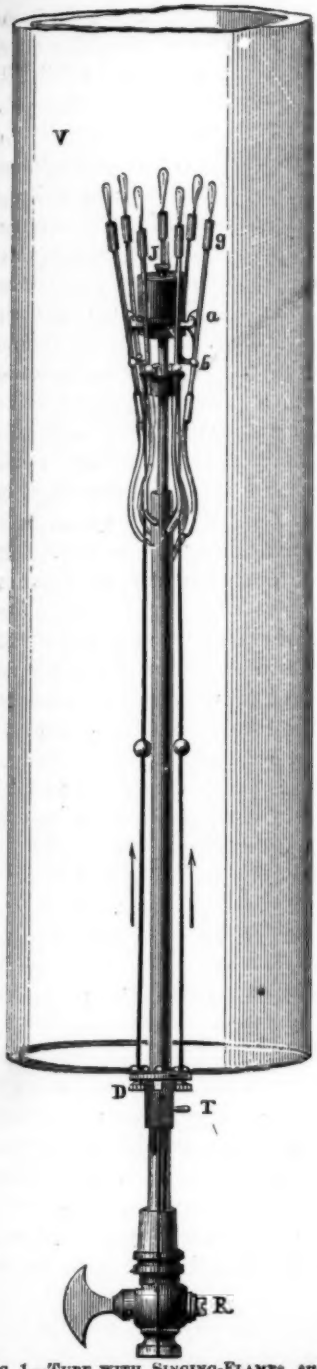


FIG. 1.—TUBE WITH SINGING-FLAMES, SHOWING MECHANISM BY WHICH THE GAS-JETS ARE MADE TO DIVERGE, AND THUS GIVE RISE TO THE SOUND.

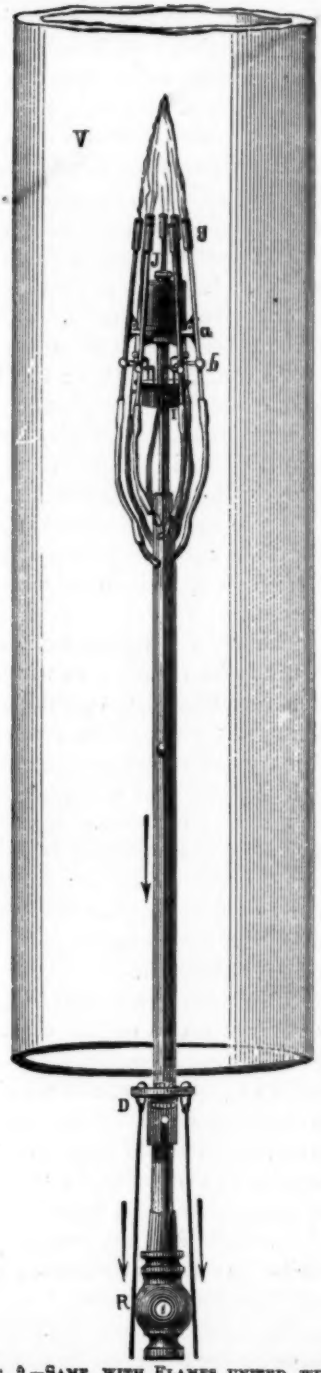


FIG. 2.—SAME, WITH FLAMES UNITED, WHEN NO SOUND IS PRODUCED.

soon as the two flames are united. If the position of the flames in the tube is varied, still keeping them apart, it is found that the sound diminishes while the flames are raised above the one-third until they reach the middle point, where the sound ceases. Below this point the sound increases down to one-fourth of the tube's length. If at this latter point the flames are brought together, the sound will not cease immediately, but the flames will continue to vibrate as a single flame would. M. Kastner, for his first experiments, used two flames derived from the combustion of hydrogen gas in suitably constructed burners. The interference of the singing-flames is only produced under special conditions. It is certain that the length and the size of the tubes depend upon the number of flames. The burners must be of a particular shape; the height of the flames does not exercise much effect upon the phenomenon. From a practical point of view, the numerous experiments effected by M. Kastner during several years have resulted in the construction of a musical apparatus of an entirely new principle, to which he has given the name of *Pyrophone* (Fig. 3); it may be called a new organ, working by singing-flames, or rather by vibrations caused by means of the combustion of these flames. This instrument may be constructed from one octave to a most extended compass.

The *British Review* humorously remarks that the pyrophone will naturally be valuable in winter, and that in America it has already been recommended to families as a means of warming small apartments, and perhaps an economical stove may be added to it for the culinary exigencies of straitened households.

The pyrophone will have in the future a poetical mission to fill in the music of concerts. A great number of composers and musicians have already admired this new organ performing by the singing of flames, or rather by vibrations determined by means of the combustion of these flames. They think it will be of great advantage in cathedrals and churches, as the most extended compass can be given to the instrument.

L'Année Scientifique, by M. Figuier, declares that the pyrophone is assuredly one of the most original instruments that science has given to instrumental music. In the large pyrophone which M. Kastner has constructed, and which they have not yet been able to bring to London, an artist can produce sounds unknown till the present time, imitating the human voice, but with strange and beautiful tones, capable of producing in religious music the most wonderful effects. So says *Le Journal Officiel de l'Exposition de Vienne.*

Journals and reviews abroad have unanimously mentioned with praise this new instrument, both from a musical as well as from a scientific point of view.

M. Henri de Parville, in *Les Causeries Scientifiques*, gives a large space to the consideration of "Singing-Flames," and states that "gas

music" made its *début* at the Vienna Exhibition of 1873. *La Nature* and *La Revue des Sciences*, edited by M. Tissandier, believe that this new instrument is destined to produce the most remarkable and unexpected effects in the orchestras of lyric theatres and in large concerts.

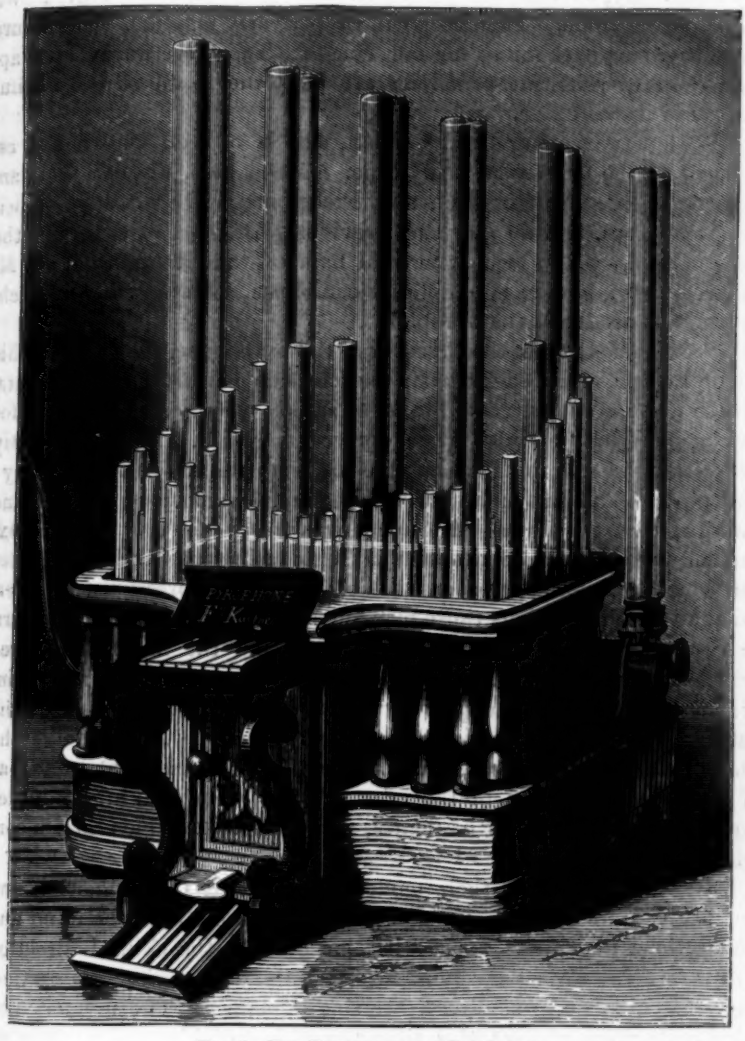


FIG. 3.—THE PYROPHONE, OR GAS-ORGAN.

The chandeliers of the theatre, besides serving to light it, may be converted into an immense musical instrument:

"When the pyrophone is played by a skillful hand, a sweet and truly delicious music is heard; the sounds obtained are of an extraordinary purity and delicacy, recalling the human voice."

The inventor has prepared a large and beautiful singing lustre, with a dozen or fifteen jets, which can be placed in the richest or most comfortable drawing-room. This lustre may be used at concerts or balls, for it can play all the airs in dance-music. It will be worked by electricity, so that the performer who plays may be seated in a neighboring room. The effect will be perfectly magical. The future has other surprises for us for our houses. The most unexpected applications of scientific principles are daily the result of the skillful efforts of learned men.

Without reckoning Prof. Tyndall, who is so well known and esteemed on the Continent, many other learned men, English, German, Austrian (like Shaffgotsche), and Frenchmen, have already studied singing-flames, but no one had previously thought of studying the effects produced by two or several flames brought together, till M. Kastner, who, by means of delicate combinations and ingenious mechanism, has produced the pyrophone.

Frederick Kastner, the inventor of the pyrophone, showed from his earliest age a very decided taste for scientific pursuits. His parents, whose fine fortune permitted them to satisfy the taste of their son for study, gave him facilities often denied to genius. They frequently traveled: the first thing which arrested his attention was a railway; this pleased him much; he had a passion for locomotives, just as some children have for horses. He was only three years old when he examined the smallest details with a lively feeling of curiosity. Later on, when he tried to reason and explain his impressions, he overwhelmed with questions those who surrounded him, wishing to learn the mechanism of these great machines, and the mysterious force which sets them to work. But, what more especially charmed him was, when the train stopped at the station, the fiery aspect of the jets of gas emerging suddenly from the darkness. At this sight he shouted with delight; such was his enthusiasm, that he seemed as if he would jump out of the arms of those who held him, in order to rush toward the jets of flames, which exercised upon him a sort of fascination.

Steam and gas, in their modern application to locomotion and lightning, were the first scientific marvels which struck the mind and the sense of the child. He studied music under the skillful direction of his father. From the age of fifteen years, in studying gas particularly, his attention was directed to singing-flames. The mysteries of electricity were also at this time the object of his study. The researches to which he gave himself up carried him on to invent a novel application of electricity as a motive force. He patented this invention. On the 17th of March, 1873, the Baron Larrey, member of the Academy of Sciences of Paris, presented to the *Institut de France* young Kastner's first memoir on singing-flames, which laid down the following new principle:

"If two flames of a certain size be introduced into a tube made of glass, and if they be so disposed that they reach the third part of the tube's height (measured from the base), the flames will vibrate in unison. This phenomenon continues as long as the flames remain apart; but as soon as they are united the sound ceases."

Passing on to his experiments, M. Kastner thus gives his account:

"I took a glass tube, the thickness of which was 2½ millimètres; this tube was 55 centimètres long, and its exterior diameter measured 41 millimètres. Two separate flames of hydrogen gas were placed at a distance of 183 millimètres from the base of the tube. These flames, while separated, gave F natural.

"As soon as the flames are brought together, which is done by means of a very simple mechanism, the sound stops altogether. If, letting the flames remain apart, their position is altered until they reach one-third of the total length of the tube, the sound will diminish gradually; and it will cease completely if the flames go beyond one-half the length of the tube; under this (one-half the length of the tube) the sound will increase until the flames are brought to one-fourth of the tube's total length. This latter point being reached, the sound will not cease immediately, even if the two flames are placed in contact one with the other; but the two flames, thus united, continue vibrating in the same manner as a single flame would.

"The interference of the singing-flames can only be obtained under certain conditions. It is important that the length of the tubes should be varied according to the number of the flames, the height of which has only a limited action or influence over the phenomenon; but the special shape of the burners is a matter of considerable importance.

"These experiments, which I undertook two years ago, induced me to construct a musical instrument, possessing quite a novel sound, which resembles the sound of the human voice. This instrument, which I term the Pyrophone, is formed by three sets of keys (*claviers*) disposed in a similar manner to that employed for the conjunction of the organ-key tables; a very simple mechanism causes every key of the different sets to communicate with the supply-pipes in the glass tubes. As soon as a key is pressed upon, the flames, by separating, create a sound; but when the keys are left untouched, the flames are brought together and the sound stops."

In consequence of this communication a commission from the Académie des Sciences de Paris was selected for the examination of this curious invention, consisting of Messrs. Jamin, Regnault, and Bertrand, three distinguished members of that Academy, who showed a lively interest from a scientific point of view in M. Kastner's discovery. After fresh experiments, M. Kastner has succeeded in substituting the ordinary illuminating gas for hydrogen gas in working this pyrophone, and his friend the Baron Larrey was again the interpreter to l'Académie des Sciences of this new discovery, which much facilitates the employment of the luminous musical instrument. M. Kastner thus expresses himself in his new report presented to the *Institut de France*, December 7, 1874:

"The principal objection which has been made to the working of the pyrophone is the employment of hydrogen gas. From a practical point of view, this

gas presents several inconveniences. It is difficult to prepare; it necessitates the use of gas-holders, whose size may be considerable. Besides, there is some danger in its use. I have therefore given up using hydrogen gas, and for a year I have experimented on the means of applying common illuminating gas to the pyrophone, which it is always easy to procure. In the first experiments which I attempted with two flames, with illuminating gas, in a glass tube, I was unable to obtain any sound, which proved unmistakably the presence of carbon in the flames. While the sound was produced in a very clear manner with the pure hydrogen gas, that is to say, without there being any solid foreign matter in the flames, it was impossible to make the tube with illuminating gas vibrate, when placing the flames in an identical condition. It was necessary, then, by some means or other to eliminate the carbon, a result at which I arrived by dint of the following method:

"When the flame of ordinary gas is examined, and this is introduced into a tube made of glass, or of any other material (metal, oil-cloth, card-board, etc.), this flame is either illuminating or sounding.

"When this flame is only illuminating, that is to say, when the air contained in the tube does not vibrate, it presents a lengthened form, and is pointed at the top. Besides, it swells toward the middle, and flickers on the least current of air. On the contrary, when the flame is sounding, that is to say, when the necessary vibrations for the production of sound are produced in the tube, its form is narrow, and large at the top. While the air of the tube vibrates, the flame is very steady. The carbon in a great measure is eliminated as if by some mechanical process.

"Sounding-flames proceeding from lighting gas are in effect enveloped in a photosphere which does not exist when the flame is merely luminous. In the latter case the carbon is burnt within the flame, and contributes in a great degree to its illuminating power.

"But, when the flames are sounding, the photosphere which surrounds each of them contains an exploding mixture of hydrogen and oxygen which determines the vibrations in the air of the tube.

"To produce the sound in all its intensity, it is necessary and sufficient that the whole of the explosion produced by the particles of oxygen and hydrogen in a given time should be in agreement with the number of vibrations which correspond to the sound produced by the tube.

"To put these two quantities in harmony, I have thought of increasing the number of flames so as to increase also the number of the explosions from the mixture of oxygen and hydrogen in the photospheres, and thus determine the vibration of the air of the tube. Instead of two flames of pure hydrogen, I put four, five, six, etc., jets of lighting gas in the same tube.

"I have besides observed that the higher a flame is, the more carbon it contains.

"I have then immediately been obliged to diminish the height of the flames, and consequently to increase the number so that the united surface of all the photospheres may suffice to produce the vibration of the air in the tube.

"The amount of carbon contained in the whole of the small flames will always be much less than the quantity of carbon corresponding to the two large flames necessary to produce the same sound. In this manner I have been able with separated flames to obtain sounds whose tones are as clear as those produced by hydrogen gas. When these flames, or rather when the photospheres which correspond to these flames, are put in contact, the sound instantly ceases.

The carbon of lighting gas, when the flames are sounding, is certainly almost entirely eliminated—in fact, it forms upon the interior surface of the sounding-tube at and below the height of the flames a very visible deposit of carbon, which increases while the air of the tube vibrates. I can now affirm that the pyrophone is in a condition to act as well with the illuminating gas as with pure hydrogen. The phenomenon of interference is produced exactly in the same condition with the two gases, the same flames occupy the same position in the tube, that is, the third part of the tube's length measured from the base. In addition to the phenomenon of interference, I believe I shall be able to describe a novel process by aid of which the sound produced by burning flames in a tube can be made to cease.

"Supposing that one or several flames, placed in a tube a third of its height (measured from its base), determine the vibration of the air contained in this tube; if a hole is pierced at the one-third of the tube, counted from the upper end, the sound ceases. This observation might be applied to the construction of a musical instrument, which will be a species of flute, working by singing-flames. Such an instrument, from a musical point of view, will be very imperfect, because the sound will not be so promptly or sharply stopped as when the phenomenon of interference is employed. If, instead of making the hole at the third, it is made at a sixth, the sound will not cease, but it will produce the sharp of the same note. In all these experiments I have clearly detected the formation of ozone while flames cause the air in the tube to vibrate. The presence of this body can, moreover, be ascertained by chemical reagents scientifically known." —Given before the *Académie des Sciences*, December 7, 1874.

Prof. Tyndall, at a lecture on January 13th, at the Royal Institution, showed experiments, according to the new principle, with an apparatus of nine flames, which worked during the evening in tubes of different sizes.—*Journal of the Society of Arts.*

ANIMAL PHOSPHORESCENCE.

AMONG the marvels which excite the admiration of the student of Nature, not the least strange is the group of phenomena known under the name of Animal Phosphorescence. We are so accustomed to associate light with heat, and to consider that fire of some kind is necessary to its production, that the imagination is appealed to with unusual force, when we find light proceeding from the body of a living animal. Yet, it is well known that the emission of light is not an uncommon characteristic among the members of the invertebrate divisions of the animal kingdom. Travelers have often expatiated on the beauty of the scenes which they have witnessed in the tropics, when the seas or forests have seemed to be illuminated by innumerable sparks of fire; and recent discoveries have shown that the luminous quality is even more common than was previously supposed. During the dredging expeditions of H. M. S. Porcupine in the years 1869 and

1870, so many of the deep-sea animals were found to be phosphorescent, that Prof. Thomson has suggested that the light necessary to the development of the eyesight which some of the specimens possessed may have had its origin in that source. In animal phosphorescence, as in all her works, Nature exhibits an immense variety in the forms in which she displays her power; in one case, the luminosity will be visible in a fluid secretion; in another, it will manifest itself through the action of a minute and complicated organ; one species of animal will shine with a yellow light; a second, with brilliant green; a third, with pale lilac; and we are acquainted with one instance in which the light changes successively to the chief colors of the solar spectrum. The causes which produce these phenomena are still very obscure. Although many forms of life are known in which the luminous quality is present, scientific men are not yet agreed on what the quality depends; and the purposes which the light serves in the animal economy are also little understood. But the phenomena themselves are often very remarkable.

Some strange theories were advanced to account for the phosphorescence of the sea, before the real cause was discovered. In 1686, an ecclesiastic, named Tachard, suggested that the ocean absorbed the sun's light by day, and emitted it again at night. About the same time, a better-known philosopher, Robert Boyle, endeavored to account for the same phenomenon by the friction which, he supposed, the rotation of the earth upon its axis caused between the water and the atmosphere. The problem was finally solved in 1749, by the discovery of luminous animalcules in the water of the Adriatic Sea; and a large proportion of the lower classes of marine animals are now known to be phosphorescent to a greater or less degree. Let us take the invertebrate divisions of the animal kingdom in their regular order, and briefly glance at one or two examples in each. Beginning with the simplest forms of life, the Protozoa, we find, in addition to certain Infusoria, the little jelly-like organism to which naturalists have given the name of *Noctiluca*, the phosphorescence of which is largely demonstrated around our coasts.

The radiated class of sea-animals possess high phosphorescent qualities. Star-fish, sea-pens, jelly-fish, sea-fans, sea-rushes, may be mentioned as cases in which the luminous quality is present among the radiata. We will take our examples from among the specimens captured during the expeditions of the Porcupine. On some occasions when the dredge was hauled up late in the evening, the hempen tangles which were attached to it came up sprinkled over with stars of the most brilliant uranium green; little stars, for the phosphorescent light was much more vivid in the younger and smaller specimens. The light was not constant, nor continuous all over the star, but sometimes it struck out a line of fire all round the disk, flashing, or one might rather say glowing, up to the centre; then that would fade, and a defined

patch, a centimetre or so long, break out in the middle of an arm, and travel slowly out to the point, or the whole *five rays would light up at the ends and spread the fire inward.* Doubtless, in a sea swarming with active and predaceous crustaceans, with great bright eyes, phosphorescence must be a very fatal gift. On one occasion the dredge came up tangled with the long pink stems of a kind of sea-pen, which were resplendent with a pale lilac phosphorescence like the flame of cyanogen gas; not scintillating like the green light of the star-fish, but almost constant, sometimes flashing out at one point more brightly, and then dying into comparative dimness, but always sufficiently bright to make every portion of a stem caught in the tangles or sticking to the ropes distinctly visible. In some places, nearly every thing brought up seemed to emit light, and the mud itself was perfectly full of luminous sparks. The sea-rushes, the sea-fans, and usually the sea-pens, shone with a lambent, white light, so bright that it showed distinctly the hour on a watch. In the neighborhood of the Madeiras, jelly-fish have been taken which emitted light in flashes, and the same phenomenon has been noticed in other parts, both in respect to jelly-fish, and, as we shall see, in respect to other animals.

Some of the most beautiful, luminous phenomena of the ocean are caused by animals belonging to the molluscous sub-kingdom, which is nearly as prolific in light-giving species as the Radiata. There is a shell-less mollusk which inhabits the Atlantic, in the neighborhood of the equator, and resembles a tiny cylinder of incandescent matter. It is microscopic in size, but prodigious numbers adhere together, until a tube from five or six to fourteen inches in length is formed, and the sea sometimes presents the appearance of a sheet of molten lava, from the number of these tubes which are floating in it. Moreover, a singular phenomenon is connected with this form of phosphorescence: the color of the light is constantly varying, passing instantaneously from red to brilliant crimson, to orange, to greenish, to blue, and finally to opaline yellow. Another highly phosphorescent species of Mollusca belongs to the family of the *Salpidæ*, which abounds in the Mediterranean and the warmer parts of the ocean. These individuals also swim adhering together in vast numbers, and produce the effect of long ribbons of fire, sometimes drawn straight in the direction of the currents, sometimes twisted and almost doubled by the action of the waves. In the Mediterranean their phosphorescence often resembles the light of the moon, giving rise to what the French term *une mer de lait.*

Luminosity is not so frequent a characteristic of the marine Articulata; nevertheless, it is exhibited by certain worm-like animals belonging to the class Annelida, and by a large number of the smaller Crustacea. In many instances the light takes the form of vivid scintillations similar to those emitted by the Medusæ, or jelly-fish, already mentioned. The appearance is sometimes very brilliant, when great

numbers of these organisms are present in the sea, the water, especially where it is agitated, being illuminated by sparks of light, varying in size from that of a pin's-head to that of a pea, and vanishing and reappearing in countless myriads. The late Prof. E. Forbes recorded instances in which he found individuals of a species of mollusk, whose visceral cavities had been deprived of their natural contents, to contain multitudes of minute crustaceans which emitted bright and rapid flashes.

If we now leave the marine world, and pursue our investigations among the inhabitants of dry land, we shall find the examples of phosphorescence much reduced in number. With few exceptions, the Articulata alone among land-animals possess this characteristic, and the class Insects furnishes us with by far the largest number of light-giving species. Thus, naturalists enumerate between two and three hundred kinds of luminous beetles, which are nearly restricted to two families, the *Lampyridæ* and the *Elateridæ*. We may take the common English glow-worm as a type of the former, and the famous fire-flies, said to serve the West Indian belles instead of jewels, as a type of the latter. In both, the organs which emit the light are very similar. Dissecting the abdomen of the glow-worm, two minute sacs of cellular tissue are seen, lying along the sides just under the skin. The cells are filled with a substance which, under the microscope, looks like soft, yellow grease. When the season for giving light is past, this yellow matter is absorbed, and replaced by the ordinary substance of the insect. A multitude of minute air-tubes surround and ramify through the sacs, terminating in a larger tube and a spiraculum, or air-opening in the skin. Free communication with the outer air is essential to the emission of the light of these two sacs, and we are thus able to account for the frequent disappearance of the glow-worm's lamp by the power which insects enjoy of closing their spiracula at will. But the *Lampyris* can in reality only partially extinguish its light; beneath the last segmentary ring of the abdomen a second pair of still more minute sacs are placed, likewise filled with yellow, greasy matter, and the light of these is not entirely under the insect's control. It may always be seen if the glow-worm be closely examined. The most curious feature connected with the organ has still to be mentioned; each of the points at which the light is visible is covered by a transparent, horny cap, divided into little hexagonal facets, and exactly similar in principle to an apparatus invented by man for increasing the diffusion of light.

The best known species of fire-fly, the *cocuja* of Spanish America and the West Indies, is an insect which resembles the common English black beetle in size, but it is dark-brown in color, and the divisions of its body are less deeply marked. The light is sufficiently strong to be of use to the inhabitants of the countries in which it is found. By inclosing three or four of the beetles in a glass bottle, a

lamp is obtained sufficient for ordinary household purposes, and travelers are said to fasten the insects to the toes of their boots, in order to illuminate the pathways at night. The light proceeds from four yellow spots upon the thorax, two of which are hidden by the wing-covers, unless the insect be in flight, when the brightness of the light is also increased by the quicker respiration caused by the motion. The luminous matter is more largely distributed than in the glow-worm, and, if the segmentary rings of the abdomen be gently pulled asunder, the light may be seen shining through the semi-transparent skin of the interstices.

Two East-Indian species of luminous beetles are especially worthy of mention. In the island of Singapore, a *Lampyris* is found which shines with an intermittent light. The insects cluster among the foliage of trees where the ground is damp and swampy, and, in accordance with some strange instinct, flash out their lanterns simultaneously. At one moment the tree will be dotted with bright sparks, which a moment later will have disappeared, excepting two or three. The intervals of darkness are about a second in duration. At these times the insects appear to be settled upon the leaves, and, if they are disturbed, they dart out at random, flashing their lights irregularly, and at shorter intervals. Borneo produces a species of glow-worm which shines with a triple row of lamps. It has been found crawling among dead-wood and leaves, the first row of lights being placed along the back, and the second and third rows along the sides.

Turning to another class among the land Articulata, we may briefly mention the phosphorescence of the centipede and that of the earthworm. Both phenomena may be seen in England, but are more common on the Continent. The centipede, which is tawny brown in color, and scarcely exceeds the tenth of an inch in diameter, is about an inch and a half in length. It frequents out-houses and arbors, where it may sometimes be found crawling along the ground, and searching for the insects on which it feeds. The phosphorescent property resides in a fluid which it secretes, and with which it can moisten the whole of its body. The light becomes more brilliant when the animal is irritated, and, if the fluid be received upon the hand, it will continue luminous for some seconds. M. Audouin, a French naturalist, residing near Paris, was witness of a remarkable appearance which was caused by luminous centipedes. He was informed that there were "earthworms" in a field near his house, glowing like red-hot coals. On going to the place to see, he found merely a few luminous streaks here and there upon the ground; but, when a spade was brought, and some of the earth thrown up, a beautiful spectacle presented itself. Great numbers of centipedes, which had collected together for some purpose, were unearthed, and the soil shone with the light which they emitted, the streaks remaining visible for many seconds, if the clods were crushed beneath the foot. Similarly, Prof.

Moquin-Tandon has recorded a case of the phosphorescence of earthworms, which he noticed on a garden-walk at Toulouse. The worms were about an inch and a half in length, and looked like little rods of white-hot iron.

It would be out of place in the pages of this journal to discuss the merits of theories which have been advanced to account for animal phosphorescence. As we have already said, Science has not pronounced any final decision on the matter. Some philosophers look upon the light as the result of the slow combustion of some combination of phosphorus contained in the animal secretions; others believe it to be a direct manifestation of vital force, acting through special organs, much in the way that electricity is produced in the torpedo or gymnotus. No doubt the problem will ultimately be solved as we advance in the study of comparative anatomy, and, in the mean time, many experiments have been made, in the hope of assisting the solution. It has been found that the luminous matter will communicate its peculiar property to liquids or solids with which it may come in contact. The light is extinguished by a cold or boiling temperature, or by strong stimulants; it also disappears *in vacuo*, but becomes visible again on the admission of the air; and it is increased by moderate heat, and by gentle stimulants. In respect to the glow-worm, the two smaller sacs of yellow matter which we described possess the curious property of shining uninterruptedly for several hours, after they have been removed from the living body, the light from other parts being extinguished immediately under similar circumstances. A simple galvanic current passed through water containing *Noctilucæ* produced no effect; but an electro-magnetic current, on the other hand, caused, after a short interval, a continuous and steady glow to issue from the water. The light disappeared at the end of a quarter of an hour, and could not be reproduced, the animalcules being evidently dead.—*Chambers's Journal.*

THE GLACIERS OF NORWAY.

By Prof. HENRY M. BAIRD.

A VISIT to Switzerland has of late become so easy and frequent an undertaking, that the glaciers around Mont Blanc and the Jungfrau have lost much of their romance and all their novelty. Every tourist climbs the Montanvert to enjoy the sensation of walking over the Mer-de-glace in midsummer, and creeps under the Rosenlaui to admire the deep-blue color of its icy vault. There is, however, another country which, in the number and beauty of its glaciers, is a formidable rival of Switzerland; but, lying as it does, out of the

ordinary track of pleasure-travel, is far less known or appreciated. Norway may, in fact, be styled with good reason the country of the glacier. True, the height of its mountains does not approximate to that of the Alps. Only one or two summits exceed 8,000 feet in altitude, and this elevation is not much more than half that of Mont Blanc. But almost the entire country stands high above the level of the ocean, while its situation so far toward the north enables the snow-fields, which are the feeders of the glaciers, to retain their vast accumulations with little loss through rain or thaw.

If the reader will glance at a map of Norway, he will see that there are two well-defined divisions: the southern, a region not destitute of flourishing cities and towns; and the northern, a narrow strip consisting of little more than a succession of headlands and islands, stretching far within the Arctic Circle. Both divisions have their characteristic, that the mountain-ranges rise in the form of wide table-lands, extending for long distances in so nearly a perfect level "that, did roads exist, a coach-and-four might be driven along or across them for many miles." The very valleys that break up their continuity are unperceived by the eye, being overlooked on account of their narrowness; and the view is interrupted only by slight undulations, or by occasional mountains of no great size. Here it is that, summer and winter, the moisture which elsewhere descends in the form of rain, spreads the successive layers of the great *Sneefon*. Prof. Forbes, in the map accompanying his interesting work on "The Glaciers of Norway," indicates not less than eighteen of these "chief permanent snow-fields" to the south of Trondhjem, and nineteen in the narrow strip north of that city. It must not, however, be concluded too hastily that the climate of Norway is cold and inhospitable; for no greater contrast can be found between countries lying in the same latitude, than between Norway and Greenland. The influence of the Gulf Stream is nowhere more strikingly traced; for, if the summers in Christiania are comparatively cool, the winters are as warm as in many places far to the south of it. Indeed, it is the remarkably equable temperature of Norway which, while it prevents the harbors from being closed by drifting ice, like those of the opposite shores of Greenland, yet allows the line of perpetual snow to come down as low as 4,000 or 5,000 feet above the sea-level. For it has been conclusively proved that it is not so much the intensity of the winter's cold, as the amount of the summer's heat, that fixes the point where frost reigns supreme throughout the year. So it happens that, while the haven of Bergen, in latitude 60°, is frozen over only twice or three times in a hundred years, or about as often as the same fate befalls the Seine at Paris, the eternal snows cover the mountain-sides in the neighborhood of Bergen at heights at which the peasant on the Jura or the Alps pastures his flocks through the long summer months.

Of late, the *savants* of Norway have been giving to the world the

results of observations upon the glaciers which they enjoy such remarkable facilities for examining. About 175 miles in a direct line to the northwest of Christiania (which is not only the capital of Norway, but the seat of one of the best universities of Europe) is a spur of the principal range included between the two inlets of Sogne and Nord—fiords. Upon its top is the largest snow-field of Norway, which bears the name of Justedal (Jostedalsbræen). Its superior magnitude and its comparative nearness to Christiania have led to its selection by two of the most eminent geologists of the country as a subject of special study. In 1869 Prof. Sexe published, as the "Programme" of the university for the first *semester* of the preceding year, a paper on the great glacier of Boium; and, in 1870, M. C. de Seue, of the Meteorological Institute, gave to the world, as the "Programme" for the second *semester* of that year, a more extended account of his observations under the title of "Le Névé de Justedal et ses Glaciers." Some of the results of the researches of these gentlemen may be of interest even to those who would soon grow weary of purely scientific details.

This immense field of snow and ice measures over forty miles in length from northeast to southwest, and from four to seven miles or more in breadth, covering, with its dependencies, according to M. de Seue's calculations, not less than some 550 square miles. The *névé*, or snow-field proper, is by no means a dead level, but the inequalities of the rocky crags are, for the most part, concealed by the thick deposit of snow, which is supposed to be at least 150 feet deep on the average, while in places it certainly fills up depressions of twice that depth. Here the snow is granular, lying in distinct layers, the product of the storms of successive seasons, and rent with frequent fissures. The glaciers spring from the edge. Wherever the jagged cliffs with which that edge bristles fall away and leave ravines, there the snow-field seeks an outlet. The glaciers are, as it were, the rills by which the great perennial reservoir discharges into the valleys below. So numerous are they, that their exact number has never been ascertained. Of glaciers of the first class, or those which pour their icy streams quite down into the valley, there are twenty-four; but, if we also include in the enumeration the glaciers of the second class, or those which remain suspended on the mountain-sides, the number is counted by hundreds. Some of the second class, it may be noticed, seem almost entitled, by reason of their breadth and depth, to be included in the higher class.

Each glacier presents many of the same phenomena as all the rest. From the moment it leaves the parent *névé*, or snow-field, the constitution of the mass is different from that of recently-fallen snow. Compressed by the immense weight of the superior strata, that lower portion of the *névé* which feeds the glacier is, at the very start, transformed into a solid ice, whose particles are cemented by the alternate

melting and freezing which go on through all but the coldest weather of the year. Whether it is the pressure of the *névé*, or the irresistible expansion caused by the action of cold upon the water pervading its great mass, that drives off the glacier, is a question respecting which the most intelligent observers are by no means unanimous. Against the theory of *weight* as the motive power is urged the fact that occasionally the glaciers are not strictly adjacent to the superior snow-field, but separated from it by an intervening space of bare rock. When once it has emerged from the *névé*, the glacier becomes a stream of ice chiefly distinguished from a fluid river by the greater sluggishness of its current. How, it may be asked, can a mass of solid ice move in a fixed channel? The question was long unanswered. Indeed, it was only slowly that the truth forced itself upon the scientific world that it does actually move at all. And, the fact being conceded, the explanation is still not altogether easy. Prof. Sexe imagines that the plastic character of the glacier, as he has observed it in the neighborhood of Justedal, resides in the ease with which the ice fractures and the equal facility with which it reunites when fragments are brought together. Thus it is that, under the immense weight of the glacier, the glassy material of which it is composed is rent when brought into contact with some solid rock standing in its bed, and that the parted streams become one again as soon as the obstacle in their way is passed. So also it is that longitudinal fissures regularly form in the lower part of the glacier of Boium, when the glacier reaches a point where it can expand in the less contracted valley, while transverse fissures open in the glacier of Suphelle at a place where the inclination suddenly becomes more considerable than it was at first, and close up as soon as the slope is again a gentle one. M. de Seue, on the other hand, emphasizes the peculiar constitution of the ice of glaciers, that is, the ice which is formed by the compression and metamorphosis of snow "The ice of the glacier," he says, "is, as already remarked, composed of distinct particles. From a piece of this ice you can, as a general thing, easily remove the particles, one after the other, without injuring the surrounding ones; and, if you should find a particle which cannot be taken out without affecting the rest, you will still notice that you can move it a little relatively to the others without harming them. Take a piece of the ice of the glaciers of a convenient size, and, in trying (so gently that it does not break) to twist or bend it, you will notice at once that there is a little changeableness in the minute portions of which it is composed."

Both M. de Seue and Prof. Sexe reject the theory of expansion as failing to account for the phenomenon of the glacier's progression, and both virtually agree in ascribing that progression to the combined influence of the enormous pressure exerted by the glacier's weight and the melting produced by the air. Unfortunately for the former

theory—of expansion—it is difficult to see how it will explain the greater motion of the glacier in precisely that part of the year and of the day when the heat is the greatest, and the influence of expansion by freezing must necessarily be least operative.

The rapidity of the glacier's motion is much greater than we would naturally expect. By a course of very careful observations and measurements, Prof. Sexe found that, in the middle of July, 1868, the ice on the surface of the glacier of Boium, near the centre of the glacier and some distance from the lower end, moved 204½ inches (Norwegian) in 211 hours. This was about $\frac{97}{100}$ of an inch per hour, and, if kept up during the entire year, would have given a total motion of about 707 feet. Here the motion was considerably greater by day than by night; in the former, exceeding $1\frac{1}{20}$ inch per hour, and, in the latter, being about $\frac{17}{20}$ only. M. de Seue, however, coming later in the same month, when the weather was less uniformly pleasant, found the average rate of progression of the same point very much diminished, viz., to less than ¾ of an inch per hour; and there is every reason to believe that, had these gentlemen been able to resume their observations in winter, they would have found that the motion during the cold weather is almost inappreciable. It is unnecessary to say that the difficulty of taking observations during half the year, on account of the temperature, and the glacier being covered over with deep snow, can scarcely be exaggerated.

It is not every part of the glacier which moves with even the rapidity mentioned. Toward the sides (and undoubtedly we should also find it so at the bottom, if we could get at it), the influence of friction can be detected retarding the motion. Near the lower end, also, the ice appeared to advance not more than one-third as fast as further up.

Of the numerous glaciers which M. de Seue describes as descending from the snow-field of Justedal, a number seem to be objects of great beauty. The photographic views which accompany his paper unfortunately fail to convey a very satisfactory idea of their appearance. The most considerable is the glacier of Trensbergdal, some nine miles long, and from two-thirds of a mile to nearly a mile in width. In several cases two or more glaciers meet, and, joining their contents, merge so thoroughly that they can be distinguished only by the *moraines*—lines of detached blocks of stone, torn from the rocks above in the downward course of the icy current, and which mark their edges even after their junction. Several are instances of what the French *savants* have called *glaciers remaniés*, the internal structure being altogether changed in consequence of their having been precipitated over ledges of rocks of considerable height. One of the smallest of the number is the glacier of Lunde, which is less than a mile in length, and only 100 feet in breadth. The interest attaching to it, however, lies in the suddenness with which it makes its spring

down from the snow-field. From the opposite side of the valley it appears like a cascade suddenly congealed in its fall; and the wonder of the spectator is excited by the apparent impossibility that such a mass of ice should thus remain suspended in mid-air. A nearer approach dispels the illusion, but scarcely the amazement of the beholder; for, after all, the inclination of the glacier is at least 45° with the horizon, nor could it maintain itself in this position but for the steep banks that inclose it, and the large mass of ice at its base which props it up.

All the glaciers of the first class are remarkable for the circumstance that their lower extremities are so little raised above the level of the ocean. While the glacier of Iökuls-fiord, in Northern Norway, is the only one in Europe, we believe, which actually comes down to the water's edge, there are several around Justedal that reach to within a few hundred feet of the sea's level, and one, that of Suphelle, to within 140 feet of it.

Of many other points developed in the valuable papers of Prof. Sexe and M. de Seue, which are of more interest to the student of physical geography and geology than to the general reader, we can enter into no discussion here.

INFIRMITIES OF SPEECH.

WHAT is necessary in order to our communicating ideas by speech? It is necessary, first of all, that ideas call up their appropriate symbols; secondly, that we remember how to say words; and, thirdly, that our organ of speech be entire—by which is meant, the whole of the muscular apparatus which is brought into action when one articulates.

Now, each of these three capabilities is liable to injury from disease. When the first is affected, the patient forgets words, or uses wrong words, in which a connection with the right ones may be more or less traceable. In the second case, an individual may have lost speech entirely, or he may retain a few words. It is no use helping him out: having forgotten how to use words, he cannot repeat them when they are used in his hearing. In the third case, there is paralysis, it may be, of muscles of the mouth, of the tongue, the larynx, etc. This last form we will exclude from consideration here. The two former constitute the disease called *aphasia* (as at least understood by some writers), and the study of it makes us acquainted with some curious facts connected with the working of that wonderful organism with which we have been endowed.

There are well-authenticated instances of persons who suddenly

found that they could not remember their own names. An embassador at St. Petersburg was once in this case, when calling at a house where he was not known by the servants, and he had to apply to his companion for the necessary information. The names of common things are sometimes strangely forgotten. The wife of an eminent jurist who consulted Dr. Trousseau, of Paris, told him that her husband would say to her, "Give me my—my—dear me! my—you know," and he would point to his head. "Your hat?" "Yes, my hat." Sometimes, again, he would ring the bell before going out, and say to the servant, "Give me my um—umbrel—umbrel, oh dear!" "Your umbrella?" "Oh, yes! my umbrella." And yet at that very time his conversation was as sensible as ever. He wrote or read of, or discussed, most difficult points of law. A patient will often use a form of circumlocution to express his meaning; thus one man who could not remember *scissors* would say, "It is what we cut with."

It may be, however, that not only are the right words forgotten, but wrong ones are substituted. The mother-in-law of a medical man (we are told by Dr. Trousseau) labored under a very singular intellectual disorder. Whenever a visitor entered her apartment, she rose with an amiable look, and, pointing to a chair, exclaimed, "Pig, brute, stupid fool!" "Mrs. B—— asks you to take a chair," her son-in-law would then put in, giving this interpretation to her strange expressions. In other respects, Mrs. B——'s acts were rational, and her case differed from ordinary aphasia in that she did not seem to grow impatient at what she said, or to understand the meaning of the insulting expressions of which she made use. Crichton mentions the case of an attorney who, when he asked for any thing, constantly used some inappropriate term; instead of asking for a piece of bread, he asked for his boots, and, if these were brought, he knew they did not correspond to the idea of the thing he wanted; therefore, he became angry, yet he would still demand some of his boots or shoes, meaning bread. One gentleman (a patient of Sir Thomas Watson) would say "pamphlet" for "camphor." Another would say "poker" when he meant the "fire;" Dr. Moore, of Dublin, has recorded the case of a gentleman who completely lost the connection between ideas and words. On one occasion the doctor was much puzzled by his patient saying to him, "Clean my boots!" Finding that he was not understood, he became much excited, and cried out vehemently, "Clean my boots by walking on them." At length it was ascertained that the cause of disquietude was the shining of the candle in his face; and that the object of his unintelligible sentences was to have the curtain drawn. When this was done, he appeared gratified. In this case, it will be noticed, the patient formed complete sentences, the power of coördination and articulation was perfect, and the intelligence was apparently unimpaired. But sometimes, where articulation may be retained, what is uttered is perfect jargon. A gentleman in Dublin,

after an attack of apoplexy, was thus affected, and in the hotel where he staid he was mistaken for a foreigner. Dr. Osborn, with a view to ascertain the nature of his imperfection of language, asked him to read aloud the following sentence from the by-laws of the College of Physicians: "It shall be in the power of the college to examine or not to examine any licentiate previous to his admission to a fellowship, as they shall think fit." He read as follows: "An the be what in the temother of the trothotodoo to majorum or that emidrate ein einkrastroi mestraits to ketra totombreida to ra from treido as that kekritest." Several of these syllables are difficult and unusual.

As indicated above, it is necessary to distinguish between the memory of *words* and the memory of *how to say* words. Where the latter memory is lost, the disorder is sometimes called *atactic aphasia*. The patient may retain a few words, and use only these. There was at the Bicêtre Asylum for many years a man who invariably used the monosyllable "Tan" when any question was put to him. (He went by the name of "Tan.") This, with the exception of an oath (S—N—d—D—!), composed his whole vocabulary. His history, long under observation, furnished some useful data with regard to the physiological relations of aphasia; but we cannot here dwell on this. Another instance, mentioned by M. Broca, was that of a man who had only four words besides his name (which he pronounced "Lelo" for "Lelong"); they were, *yes*, *no*, *three*, and *always*. He used *yes* and *no* at proper times, but he made use of the word *three* in order to express any number, although he knew well that the word did not always convey his meaning; and corrected the mistake which he made in speaking by holding up the proper number of fingers. Whenever *yes*, *no*, and *three*, were not applicable, he used the word always (*toujours*). M. Broca infers from this man's case—1. That he understood all that was said to him; 2. That he used with judgment the four words of his vocabulary; 3. That he was of sane mind; 4. That he understood written numeration, and at least the values of the first two orders of units; 5. That he had lost the faculty of articulate language alone. It is to this atactic aphasia alone that M. Broca limits the term *aphasia*. Another example of it may here be given from Dr. Trousseau. A lady came to consult him with her son, aged twenty-five. This young man could articulate two words only, *no* and *mamma*. "What is your name?" "Mamma." "What is your age?" "Mamma, no." He yet knew that he did not answer as he ought. He had taught himself to write with his left hand, the right being paralyzed, but had not got beyond signing his own name, "Henri Guénier." "Since you write your name," Dr. Trousseau told him, "say Guénier." He made an effort, and said, "Mamma." "Say *Henri*." He replied, "No mamma." "Well, write *mamma*." He wrote *Guénier*. "Write *no*." He wrote *Guénier*. However much he was pressed, nothing more could be got from him.

There are various remarkable phases of this inability to articulate. One man in the Paris asylum would say "*Consisi;*" and it might be expected that he could easily say "*con-con*" or "*sisi*," but it was only after several days' trying that Dr. Trousseau got him to say the former, and he never could say "*sisi*" alone. Another aphasic patient, a woman, could say very well, "*Bonjour, monsieur;*" but could never be got to say "*Bonbon.*"

Aphasic patients are, as a rule, beneath the average of other men, as regards intelligence, and considerably beneath their former selves, when the comparison can be instituted. There is, however, a very rare form of aphasia in which the intellect is unaltered, memory is good, the patient writes easily, and expresses his thoughts correctly in writing as educated deaf-mutes do. The recovery of the art of writing (where it is recovered) is gradual.

The physiology of aphasia is a subject that has been a good deal controverted, but it now appears possible to explain most of the phenomena by the nature of lesions, and by the very constitution of the nervous system. The following representation of the facts (which we take, in the main, from an eminent French observer, M. Charles Richet) will convey some idea of what medical men hold on this subject.

The nervous system (let it first be understood) is formed of a central part, the brain and spinal cord, and of a peripheric part, the nerves. The nerves are simple conductors, while the central part perceives sensations and determines movement. Now, in this central part, the cerebro-spinal, inclosed by the cranium and vertebral column, as in a case, there are two distinct elements; an active element, and a conducting element. The white substance is the conducting element; the gray substance the active. The gray substance forms a thin column, which is the central part of the spinal cord, and is continued into the brain where it enlarges. The whole of this column is surrounded by white substance; and in the higher types of vertebrates we find added the so-called "cerebral convolutions." Here the white substance of the brain is folded in various directions, and its entire surface is covered with a thin layer of gray substance. To this elementary exposition it need only be added that the gray substance in brain or cord seems to be formed, not by a single cord, but by a series of nuclei, or centres, placed end to end and connected together. These are sometimes called *ganglions.* It is in the outer gray substance that will, intelligence, instinct, seem to reside. If the upper part of the cerebral hemispheres be cut in a pigeon, the bird loses all activity: it is incapable of moving voluntarily. It is an automaton which flies when thrown into the air, which swallows when a grain is placed in its throat; but which is without consciousness. Its existence is purely vegetative.

If, instead of the superficial part of the brain, it be the gray axis,

the spinal cord, that is injured, all the nerves coming out from it are paralyzed; and, so long as the ganglion from which the respiratory nerves come is not affected, life is possible, however numerous the paralyses. Now, it appears that, for each of our functions, respiration, movements of the heart or of the eye, deglutition, etc., there is a special ganglion of the gray substance forming part of the central column, and charged with the regular coördination of the movements necessary to the accomplishment of this function. Thus, e. g., in order to voluntary swallowing, it is first necessary that the will determine movements of deglutition, then that this order be transmitted to the nervous centre of deglutition, i. e., a small body of gray substance which anatomists have called the *olivary* body (on account of its form), and which presides over this function.

Between these two centres, however, of which one is producer and the other coördinator, there is a third, the centre of impulsion. The central gray substance, expanding in the brain, forms two large ganglions surrounded entirely by white substance, except at their base, which is connected with the central axis. These two large cerebral ganglions are called respectively the *optic layers* and the *corpora striata*. It is they that determine the motor impulsion, that transmit to such and such a ganglionic nerve-centre the order to put itself in motion. Thus the nervous influx arising from will proceeds from the superficial nerve-cells to the ganglionic centres of the brain, then to the ganglionic centres of the spinal cord, issuing in regular movement. It is something like the case of an electric telegraph, with stations and intermediate relays.

Now, coming to aphasia, it seems to have been well established (from *post-mortem* examination) that there is a limited region of the superficial portion of the brain, on which the faculty of articulate language is dependent, and impairment of which gives rise to aphasia as understood by M. Broca. First of all, it is in the left hemisphere (a curious thing in an organ so symmetrical as the brain). Next, it is in the anterior part of this hemisphere; and, lastly, to be more precise, it is the third cerebral convolution. Agreeably with this, it is found that a great number of aphasic patients are paralyzed in the right side of the body. It must be understood that the nerve-fibres cross over from the left hemisphere.

We may regard the anterior convolutions of the left hemisphere as a sort of *logopoietic*, or word-forming apparatus, where the previously vague idea becomes precise and distinct, taking a word-form and becoming representative. Lordat distinguishes these two forms of intelligence as the interior *logos* and the exterior *logos*. It should be remembered that this conception is a pure hypothesis; but it is in accordance with the facts.

But, for a phrase thought by us to come to the ear of another, a second series of apparatus is required. This is the continuous chain

going from the periphery of the convolutions to the central gray column. The nervous influx first goes into those two large ganglions of gray substance, the *corpora striata* and the *optic layers*. Probably these organs transform the phrase thought into voluntary movement. From the *corpora striata* the vibration is transmitted along the central axis to the olivary bodies, which are the coördinating apparatus, and which regulate and direct the movement. From the olivary bodies proceed nerves to the lips, the larynx, the tongue, the pharynx, the palate—all the vocal organs concerned in production of language. Pathological facts teach us that these different apparatuses may be destroyed separately, and there is then involved the absolute loss of such and such a function.

Thus in a case recorded by Dr. Winslow, the man had retained the faculty of language; he could write the words and phrases which he thought of; but, when he tried to speak, he only uttered confused sounds. In this instance the olivary bodies were alone affected. The faculty of language remained intact; the vocal apparatus was not injured; but the apparatus of transmission was profoundly altered.

In other cases, again, it is the organ of thought itself that is diseased. There is an affection well known to physicians who study the insane, and which is called general paralysis. This disease begins in the periphery of the convolutions, which are devoured (so to speak) by a slow inflammation characterized by intermittent extensions. One may take account of the disorders it causes by the state of intelligence of the patients. At first the inflammation produces an intellectual excitation, which expresses itself in mad acts. Each time a fresh access of madness is observed, one may pretty surely infer a new extension of the disease. But at length, when the whole outer surface of the hemispheres is destroyed, there is no longer either thought, or will, or instinct; the unhappy subjects are plunged in a state of somnolence and stupor, from which nothing can rouse them. They do not speak, because the organ of thought no longer exists.

It is probable, then, that between the organ of thought and the vocal organ there is a third organ—the organ of words, and it is a lesion of this which properly constitutes aphasia.—*English Mechanic.*

ARCTIC ICE-TRAVELS.

By CLEMENTS R. MARKHAM, F. R. S.

FORMERLY exploration in the arctic regions was entirely performed by ships. On one or two occasions only were sledge-parties dispatched for the purpose of discovery, and then on a very reduced scale. During the search expeditions, however, after Sir John Franklin and his gallant companions, the system of sledge-trav-

eling was matured, and has now, owing to the genius of McClintock, Mecham, Hamilton, Osborn, and Richards, reached a high state of perfection. In fact, in these days the sledge must be regarded as *the* principal means of arctic exploration, and the ship only as the auxiliary. It is to Sir Edward Parry that the introduction of sledge-traveling is due, but the very primitive and cumbrous machines used by him, during his many successful voyages to the arctic regions, are no more to be compared with the light and useful sledges which are being constructed from the designs of Sir L. McClintock for the expedition of 1875 than is a brewer's dray to a light gig. We propose to institute a comparison between the modes of traveling past and present, and to describe the work that will fall to the lot of an exploring expedition during the space of twelve months. The best route for polar exploration is the one that has been so unanimously advocated by all arctic authorities both of our own and other countries, and the one that is to be adopted by the expedition about to leave our shores. There are many reasons why the route *via* Smith Sound is superior to and more advantageous for polar exploration than any other. We know that the United States exploring-ship Polaris succeeded by this route in reaching a very high northern latitude—in fact, the highest latitude that a ship has ever attained, and that in a remarkably short space of time and with perfect ease. The shores of this narrow sound are teeming with animal life. In Dr. Hayes's expedition upward of 200 reindeer were shot during the winter, walrus and seals were abundant, and there were quantities of ducks and little auks in the summer. Where the Polaris wintered herds of musk-oxen found pasture, rabbits abounded, and large flocks of birds came northward in the summer months. This in itself is of the utmost importance, as with well-organized hunting-parties, such as will be formed on board our exploring-ships, the crews will be supplied with fresh meat. The Smith Sound route is the best adapted for exploration by sledges, and in case of mishap or any unforeseen accident befalling the ships, it would simply be a matter of time for the ship's companies to travel south and reach the Danish settlements, or one of the Scotch whalers that annually frequent Baffin's Bay. The importance of reaching in the ships a high latitude lies in the consideration that every ten miles made good in the ship toward the north is two days' sledge-traveling saved. The ships ought to leave England in the month of May or June. In a fortnight Cape Farewell, the south extreme of Greenland, would be reached, off which the first ice is invariably met. This in a great measure consists of small, detached fragments, probably broken off the land-ice, with which Greenland at the early part of the year is surrounded, by the motion of the waves. Icebergs are also fallen in with in this locality. The scene on a fine clear day in Davis's Straits, to one visiting these regions for the first time, is indeed very grand. Huge icebergs sailing majestically along, in every conceivable

shape and form, at times making the navigation so intricate as to call forth the utmost vigilance and watchfulness from those on board, their edges adorned with pendent fringes of icicles, while the bright blue and green tints reflected from these huge mountains of ice tend to render it a scene such as is hardly to be realized by those who have never witnessed it. The Danish settlement of Lievely, or Godhavn, at the southwest extreme of the island of Disco, and Upernavik, the most northern settlement, are reached, dogs are purchased and taken on board, Esquimaux dog-drivers engaged, and the necessary skins and dog-food procured.

Now commences the first really serious work of the exploring ships. One day's run from Upernavik and Cape Shackleton is reached, from which is sighted the dreaded floe-ice of Melville Bay, a spot which, until the introduction of steam, has proved fatal to many a gallant bark. To an inexperienced eye this ice seems of an impassable and impenetrable nature, but to those acquainted with ice-navigation a lead may appear through which the ship is steered. Much depends on the wind in making a passage through Melville Bay. If it is calm, or if the wind is from the north, the ice loosens, and ships must then make the best of their time and push on speedily; but if the wind is from the south it causes the loose ice-floes of Baffin's Bay to pack against the land or fixed ice, and woe betide the unfortunate vessel that should be nipped between the two! The only means of escaping destruction is by cutting a dock in the land-ice and warping the ship into it. Steam, however, has of late years produced such a revolution in ice-navigation, that the animated scene of 200 or 300 seamen landed on the floe, busily employed in the operation of cutting docks, is now seldom or never witnessed. The last English Government Expedition, that of Sir Edward Belcher, took no less than five weeks going through Melville Bay, although the expedition was accompanied by a couple of steam-tenders, commanded by experienced and energetic officers. When Commander Markham went through Melville Bay in 1873, in the steam-whaler Arctic, the time occupied was only sixty hours, and last year the whole of the whaling-fleet succeeded in making the passage in three days! Such is the advantage we have gained by the aid of steam. Detention in Melville Bay is, even with a steamer, probable, but seldom for a long duration. When such is the case, ice-anchors are got out, and the ship is moored to the floe, waiting an opportunity for the ice to ease off. Perhaps it is only a neck of ice that prevents the ship from proceeding; in which case, with a full head of steam, the objectionable barrier is rammed, and the ship is forced through, emerging into the open water beyond. Even during these detentions the time may be beguiled in shooting looms and rotges, which are capital eating, harpooning narwhals and stalking seals, or in the more exciting sport of bear-hunting. Sport, together with the strange and novel scenery, and the beauties of the midnight sun,

makes life, even in Melville Bay, charming and enjoyable. In former days the monotony of the detention in this bay was indeed wearisome, and the laborious work of tracking the clumsy, unwieldy ship, or cutting docks in the floe, was fatiguing and irksome in the extreme.

In the latitude of Cape York the "North Water" is generally reached, and this, so far as we know, has always been navigable to the entrance of Smith's Sound, and to a much higher latitude.

We will now assume that the month of September has arrived, and that the expedition has succeeded in reaching, we will say by way of illustration, the latitude of 84°. We are, of course, anticipating an open season, and a most favorable and prosperous run. Bay or pancake ice, which is newly-formed ice, is now forming, and it is absolutely necessary to seek winter quarters. A snug harbor is, if possible, found, protected as much as possible from the prevailing northeasterly winds, and arrangements are at once commenced for securing and housing-in the ship. One part of the ship's company is told off for this latter duty, which consists in unbending the sails, unreeving running rigging, sending down upper spars, and housing the ship in with a covering made of tilt-cloth. This is spread on spars that are secured fore and aft between the masts about fifteen feet above the deck, sloping down to the bows and the stern, and ridge-ropes set up to the rigging, about seven feet above the bulwarks. One entry only is made as a gangway, on what would be the lee-side of the prevailing wind. An observatory is built, and an ice-wall made to inclose the ship, the space inside the wall being kept free and clear, to be used for exercise, and as a promenade during the winter months. In the mean time, the other part of the ship's company will be preparing the sledges, and making the necessary preparations for the autumn sledge-traveling, all of which will have been carefully organized beforehand.

We now come to the most important feature of arctic work, namely, the sledge-traveling, which was first introduced by the late Admiral Sir Edward Parry, but which is most indissolubly associated with the name of McClintock, whose perseverance and energy have brought this system of traveling to such a state of perfection that we rely chiefly on its aid to procure for the forthcoming expedition that success which all England heartily and eagerly desires, and hopefully anticipates. Before describing the arrangements for the autumn traveling, let us take a brief retrospect of the sledging undertaken by Parry fifty-five years ago.

Parry at Melville Island, in 1820, did not commence traveling operations until June. He used a cart, in all probability formed of the field-piece carriage and limber supplied to the ship. He was away only fourteen days, having traversed a distance of about 180 miles, averaging 12′ per diem. His party consisted of twelve, including himself, out of which five were officers. On account of the excessive glare caused by the sun on the snow and ice, the party traveled during the

night, when the sun was low. By this arrangement they had the advantage also of sleeping during the comparative warmth of the day. The daily allowance of provisions per man was 1 lb. of biscuit, ⅔ lb. of preserved meat, 1 oz. of sugar, and ½ pint of spirits. The total weight carried on the cart was 800 lbs., consisting of two blanket-tents, wood for fuel, three weeks' provisions, cooking-apparatus, three guns, and ammunition. In addition to this, each man had to carry a blanket-bag, a haversack with one pair of shoes, one pair of stockings, and a flannel shirt, weighing from 18 to 24 lbs. Their tents were made of blankets, with two boarding-pikes fixed across at each end, and a ridge-rope along the top, the lower parts of the blankets being kept down by placing stones on them.

In his attempt to reach the pole, in 1827, Parry started in the same month of June, with four officers and twenty-four men, with seventy-one days' provisions, in two flat-bottomed boats named the Enterprise and Endeavor, so constructed that they could be used as sledges, and drawn on the ice. They were 20 feet long, and 7 feet broad, with a bamboo mast 19 feet long, a tanned duck-sail, steer-oar, fourteen paddles, a sprit and boat-hook. Each boat, with stores, etc., complete, weighed 3,753 lbs., making the weight for each man to drag 268 lbs.! in addition to four light sledges, weighing 26 lbs. each. The boats were squarely built, without regard to shape or symmetry, their beam carried well forward and aft. In order to secure elasticity during the rough handling which they must needs encounter from frequent concussions with the ice, their frame was first covered with a water-proof coating, consisting of tarred canvas, then a thin fir planking, which latter was covered with felt, and outside a thin oak planking, the whole secured to the timbers of the boat by iron screws. On either side of the keel was a stout wooden runner, shod with metal, similar to that of a sledge, on which the boat would travel when being dragged over the ice. A spar, made of hide, was secured across the fore-end of the runners, to which the drag-ropes were attached. The daily allowance of provisions for each man was 10 ozs. of biscuit, 9 ozs. of pemmican, 1 oz. of cocoa-powder, and 1 gill of rum, besides 3 ozs. of tobacco per man per week. The fuel used was spirits of wine, of which 2 pints were used daily.

This was one of the most laborious and heart-breaking journeys that can be conceived, as, owing to the lateness of the season, the traveling was chiefly over loose pack, which on account of unusual heavy rain was broken and rotten; added to this, the hummocky nature of the firmer ice necessitated a constant packing and unpacking of their sledges, the same ground having to be traversed as many as three and sometimes four times. Parry nobly persevered, fighting against obstacles that would have daunted and appalled many a brave man, until it was known that the drift of the ice on which they were traveling was faster to the southward than the progress they were mak-

ing to the northward, and they were in consequence reluctantly compelled to abandon their project and return to their ship, which they succeeded in reaching after an absence of sixty-one days. Although before turning back the party had traveled over 292 miles of ground, their greatest distance from the ship was only 172 miles, so much had the set drifted them to the southward. Notwithstanding these obstacles, and the enormous weight which each man had to drag, the latitude attained by Parry on this occasion has never been reached by known man. The experience gained during this enterprise has shown us a great deal. It proved that the allowance of provisions for the amount of work required, and for the hardships endured, was insufficient; that the sledges were too cumbrous and heavy, and the weight that each man was required to drag was far in excess of his capabilities, and that the season was so far advanced as to cause not only the ice to be broken up, and thereby affected by the current, but the mild temperature had so rotted and thawed the surface of the floes on which they traveled, that the greater part of their journey was performed walking through sludge and water. As during his former sledge-journey in 1820, Parry preferred traveling by night, and resting during the glare and warmth of the mid-day sun.

The next authentic accounts of sledge-traveling we hear of are those parties organized by Sir James Ross in 1849 for the relief of Sir John Franklin, in which Sir Leopold McClintock, then a lieutenant, received his first initiation in that important branch of arctic work, which through his means has reached such an admirable state of perfection. But to what consequences did these pioneer expeditions lead? Experience had to be gained, and the privations and sufferings endured by those engaged in these early expeditions are now compensated by the lessons they have taught us. They started with two sledges, each drawn by six men, carrying with them their tent and thirty days' provisions. Other parties with more provisions followed on their route. They were away forty days, having accomplished a search over 500 miles of unknown country, but we are told that out of the twelve men that started, seven only returned in comparative health, the remaining five having quite broken down under fatigue. The party suffered severely from hunger, frost-bites, blistered feet, and rheumatic pains, caused by their continually walking through water on the ice and deep soft snow. Two of them, being unable to walk, were brought back on the sledges. Sir Leopold himself acknowledges that, after his return to the ship, he did not lose the sensation of *constant hunger* for a fortnight.

During the next expedition, that of Captain Austin, in 1851, from the experience which he had already gained in sledge-traveling, Sir Leopold McClintock, by adopting a system of fatigue-parties, was enabled to prolong his absence from the ship to eighty days, and to extend his journey to a distance of 900 miles. During this journey,

partly traveling over the same ground as Sir Edward Parry, he discovered the encampment of his predecessor, and found the remains of his broken cart, and the records left by him thirty years before. Even the remains of Parry's last feast, "a sumptuous meal of ptarmigan," lay strewed about in the shape of bones, by no means decayed, but merely bleached from exposure. McClintock and his gallant party returned to their ship after this long absence, reduced a little in flesh, but *not* in health or spirits. They had already benefited from the experience of former expeditions.

During the expedition of 1852, the last dispatched by Government in search of our missing countrymen, we find Sir Leopold McClintock in command of the steam-tender Intrepid, acting under the orders of Captain Keilett. On this occasion, Sir Leopold had, through the assiduous and constant exercise of his inventive talent, so improved on his former knowledge of sledge-traveling, that he was enabled to remain away from his ship for a period of 105 days, during which time he traveled over no less than 1,400 statute miles, and this, too, under no very favorable circumstances, as the ice over which he had to journey was old and unusually rugged, snow lay very deep, and Melville Island had to be crossed and recrossed, in addition to which, owing to the few men from whom he had to select his party, he was obliged to portion out to each man a much heavier load than had ever been attempted before. They were most fortunate in obtaining plenty of game. Musk-oxen, deer, and ptarmigan, were seen in abundance, and many shot, the fresh meat from which materially assisted in the preservation of the health of the party.

The words of Sir Leopold McClintock are very true, and very significant, in epitomizing the results of arctic ice-travel. He says: "Truly may we arctic explorers exclaim, 'Knowledge is power!' It is now a comparatively easy matter to start with six or eight men, and a sledge laden with six or seven weeks' provisions, and to travel some 600 miles across desert wastes and frozen seas, from which no sustenance can be obtained. There is *now* no known position, however remote, that a well-equipped crew could not effect their escape from by their own unaided efforts. We *felt* this, and by our experience, gained in a cause more glorious than ever man embarked in, have secured to all future arctic explorers a plan by which they may rejoin their fellow-men."

Before detailing the operations connected with the autumn sledge-traveling, it will be necessary to explain the construction of the sledge, and the amount of provisions and stores that will be required for an extended journey. We propose, therefore, to give an account of an eight-man sledge, provisioned and stored for a period of eight weeks, copied from Sir Leopold McClintock's notes. The following particulars describe, with considerable exactness, the equipment which is now being prepared in Portsmouth Dock-yard for use in the forthcoming Arctic Expedition:

The sledges are made of American elm, and the runners are shod with steel. The cross-bars are lashed to the bearers with strips of hide, which are well soaked in hot water and put on while warm and wet, so that when cold they will shrink tightly into their places.

The drag-ropes should be of two-inch whale-line, or better still of hemp or manila rope, which is lighter, six fathoms in length, and these could also be used for tent-ropes. They should be middled and the bight toggled to the span on the fore-end of the sledge. The span should be of the same size and description of rope, fitted to go with an eye over the end of the horn at the after-end of the sledge, rove through one or more grummets on the cross-bars, through a hide-strop round the runner, and taken well down below the foremost horns, so as to keep it as near as possible to the best angle of traction, namely, 15°. The bight of the span should be about three feet in front of the sledge, having a toggle and eye in the middle for the purpose of connecting the drag-ropes. To keep the contents from falling down between the cross-bars, two fore-and-aft lines are clove-hitched round each and stretched taut along—over these is laced a width of stout canvas, on which rests the sledge trough or load, and is called the sledge-bottom. The sledge-trough, although not absolutely necessary, is extremely useful, as it enables the sledge to be loaded more speedily, and prevents small packages from tumbling out; it is also most useful in the event of much wet. It is simply a canvas body in which the stores are packed, and weighs, without being oiled, eight pounds.

The drag-belts are made of light loose girth, three inches wide, long enough to go over a man's shoulder, having a strong eyelet-hole worked in each end, into which is spliced a piece of one-inch rope, having a thimble on it. Round this thimble is spliced a small piece of rope, having at its other end a bung toggle, usually a circular piece of copper. This is attached to the drag-rope after the manner of a Blackwall hitch, the advantage being that the man can detach himself at any instant. Turk's-heads worked on the drag-ropes point out where the men are to attach themselves. The sledge-lashings consist of about twenty fathoms of one and one-quarter inch untarred rope, and are used for lashing the lading on the sledge.

Too much care cannot be taken in the stowage and lashing of the sledge. The greatest weight should be over the centre cross-bar, diminishing toward the end, so that the sledge will rise easily and gradually, and descend in the same manner, when traveling over rough or hummocky ice. A well-packed, that is, a well-trimmed, sledge is dragged with less exertion, and less jerking to the men's shoulders, when going over rough ice, than one that has been carelessly packed. The lashings should be passed so tight that, should the sledge be upset and roll over, its contents would remain intact. It will be found convenient to fit a light cross-bar across each end of the sledge, for the purpose of spreading a light netting, on which to stand the cook-

ing-utensils, as they are usually the last things to go on the sledge and the first things to come off it.

Dog-sledges are of a smaller size, and the different fittings and gear are therefore proportionately small. The driver in a packed sledge usually walks behind, holding on to the back of the sledge with one hand while with the other he uses the whip, which latter has to be kept in constant use.

A most important auxiliary in sledge-traveling, and one which must not be omitted, is the sledge-sail; by its aid, with a fair wind, the men are greatly relieved in their laborious work of dragging. The mast is extemporized out of two tent-poles—which should, if possible, be of bamboo—used as sheers, the heads being connected by an iron band, on which is stropped the block through which the halyards are rove; the heels of the sheers are stepped into a thimble on each side of the sailing-thwart, which is placed across the sledge on top of every thing, immediately over the midship-upright, and is lashed down to the bearers. The object of having it so high is that a loftier sail may be spread. The tent-ropes are used as guys, and a hand lead-line as halyards. Each sledge should have what is called a "store-bag," made of light duck, and containing sail and sewing-needles, a palm, twine, thread, a ball of spun-yarn, two yards of green or blue crape, awls, waxed ends, lucifer matches, record-cases, tent-brush, clothes-brush, and spare wicks for cooking-lamps.

With an eight-man sledge detached for an extended journey of seven weeks the total weight of the laden sledge would be 1,646 pounds, being 235 pounds for each of the seven men to drag. If *all* the circumstances are favorable, Sir Leopold McClintock is of opinion that this is not too much; of course the men must be picked and well trained to sledge-work before setting out. Under no circumstances should this weight be exceeded, or even maintained for more than a very few days. When sledges are traveling in company, one gun each and much less ammunition will suffice. The sledges being prepared and every thing in readiness for a start, the men are assembled dressed in the following manner:

	SPARE.
1 Flannel or wove woolen frock.	
1 Thick Guernsey frock.	
1 Loose serge or cloth frock	1
1 Pair of good duffle (or box cloth lined with flannel) trousers.	
1 Light close duck jumper and trousers as "overalls."	
1 Pair of worsted stockings	1
1 Pair of wove woolen drawers	1
1 Pair of blanket feet-wrappers	2
1 Pair of wadmill boot-hose	1
1 Pair of moccasins	3
1 Pair of mitts	2
1 Welsh wig	1
1 Cap, veil, and face-cover.	
1 Comforter.	
1 Pair of colored spectacles.	
1 Pair of canvas boots	2

Towel and soap, also a water-bottle and gutta-percha drinking-cup. Spare clothing in knapsack, altogether weighing twelve pounds.

The clothing supplied by Government to the various search expeditions was made of the most superior material, and was found excellent. It is hardly necessary to describe the different articles. Particular care should be exercised in the selection of under-clothing, which should be of the best and warmest substance. Outside clothing should fit loosely. In place of the overall jumper and trousers, which are used merely as "snow-repellers" to keep out the light snow-drift, a suit made from the skin of the moose-deer well smoked would be found advantageous; the jumper should have a hood to pull up over one's cap in bad weather, and should have a large pocket in front to put one's mitts in when not in use. The moccasins should be made large, so as on no account to cramp the foot. They are only intended to be worn during extreme cold.

The daily allowance of provisions for those engaged in sledge-traveling is as follows: For each man, 1 lb. pemmican, ¼ lb. boiled pork, 14 ozs. biscuit, 2 ozs. preserved potatoes, 1½ oz. prepared chocolate, ½ oz. tea and sugar, 1 oz. concentrated rum; 4 ozs. fuel being used daily for each individual; also a weekly allowance per man of 1¾ oz. salt, ¼ oz. pepper, 1 oz. curry or onion powder, and 3 ozs. tobacco, making a weekly allowance per man of 19 lbs. 3 ozs., which is a very liberal one, and well adapted to long journeys in the most severe weather. In fact, at first starting, the men are not able to consume the full amount allowed of pemmican, but after a few days' hard work and exposure this little difficulty is soon overcome. Fuel may consist of different materials. There is the camphorated spirits of wine, whose great charm consists in its being camphorated, and therefore cannot well be tampered with by the men. Methyllated spirits of wine has also been much used, and is cheaper than pure alcohol. Sir Leopold McClintock, in the Fox, used crude cocoa-nut oil, which he found very useful and very cheap. Its advantages over tallow are: 1. That it cooks much more rapidly; 2. It makes very little smoke (an important item); and, 3. There is nothing disagreeable in smell or taste about it.

Great care must be taken in the stowage of provisions, and, in fact, in all that relates to the equipment of a sledge, as it is most important that the greatest economy in the matter of weights should be arrived at. The officer conducting the sledge-party is, of course, responsible that the necessary instruments are taken that will be required for fixing astronomically different positions, and for delineating the coast-line. Every thing being in readiness for a start, the sledges, which we will say are six in number, with their distinguishing flags (to each of which there is usually a history attached) fluttering bravely in the breeze, are drawn up outside the ship, the men, cheerful and joyous, with their drag-ropes in hand, the officers with their rifles slung across their shoulders, receiving their parting instructions, all

hopefully confident of success, and all eager to accomplish all that man can do. It is an animated scene, all are merry and glad, with the exception, perhaps, of those few that must of necessity remain behind, to look after the ship. The crews of each sledge consist of an officer and seven men, and by a system which has already been adopted with great success on previous occasions, one sledge could be advanced to at least fifty days' journey from the ship, or more correctly twenty-five days out, and depots placed for the return-journey. This is effected in the following manner: After traveling in company for a week, No. 6 sledge will complete the remainder to their full amount of fifty days' provisions and return, the remaining five proceeding on their way. When six more days have elapsed, No. 5 sledge will return to the ship, having filled up the remaining four to what they originally started with, and so on until No. 1 sledge is left to proceed by itself. In the mean time the sledges that have returned will immediately reprovision, and will lay out depots for the use of, and meet the returning sledges, ready to render any assistance they may require.

As an outline of the daily routine observed by sledge-parties during their arduous employment may be of interest, we will briefly refer to it. As it may be advisable some time to travel during the night, for the same reason that Parry did, we will not name any hour, but merely the time of rising and going to bed. We will begin with the commencement of the day's work. The first thing to be done is to awaken the cook of the day, who at once sets to work to prepare breakfast. The time occupied in preparing this meal is usually about an hour from the time he is called. When nearly ready, he brushes off the condensation that has taken place during the night, from off the coverlet, and from the inside of the tent, and then arouses the whole party. If the weather is very severe they sit up for breakfast in their bags, but if not, they roll them up, as also the tent-robes, put on their moccasins, etc., ready for the march, and then, sitting on their bags and knapsacks, discuss their morning meal. The sleeping-bag is, as its name designates, a large bag made of the Hudson's Bay three-point blanket or of duffle. It is about seven feet long, and is best fitted with the opening in the side instead of at the top, as in this way it is more convenient to get into and out of, and the more readily enables a man to sit up and keep it over his head while eating his meals or while writing.

When breakfast is finished, the biscuit and pork to be used for lunch should be measured out, and placed in the luncheon haversack; dilute the day's allowance of rum, and any water that may be remaining put into the men's water-bottles. Issue to the cook the day's allowance of stearine, and put the requisite amount of spirits of wine into the lamp. The cook trims both lamps, and is then relieved by the cook whose turn it is for the next twenty-four hours. In large parties

it would be as well to have a cook's mate in addition, who would succeed the cook when his term of office had expired, a fresh hand being installed in the capacity of cook's mate. The whole of the tent-furniture must be well brushed, so as to get rid of any snow-drift, or condensation, and the tent itself should be well shaken before being stowed on the sledge, which is then packed, and the march begun. The officer takes his observations for time or variation, also the bearings of land, temperature, etc., at a regular time before starting.

After marching for about six hours, halt for twenty minutes for lunch. The spirit-lamp is used to dissolve snow, and the grog, pork, and biscuit, are issued. If the wind is fresh, turn the sledge at right angles to it, and with sledge-sail to form a lee, sit-down. If very severe weather, pitch the tent, and sit inside without any tent-gear, or stop only five minutes for grog and biscuit. When halted for the night, and the tent is pitched, one man, after brushing himself well, goes inside, and receives and places all the gear, robes, knapsacks, sleeping-bags, etc. The cook prepares supper without delay. When all the work is completed the men take off and hang up their moccasins or boots and blanket-wrappers, either upon the tent-ropes outside, or on the tent-line inside, according to the weather, brush themselves well, divest themselves of their overalls, and take up their respective places in the tent, the officer always at the head of the tent, the cook and cook's mate nearest the entrance, so that their rising does not disturb the rest. Supper consists of warm pemmican, the quantity in each pannikin always being carefully equalized before being served out, then a drink of tea or water, when pipes are lighted and the party compose themselves for their night's rest; songs and yarns, if not too cold and exhausted, bringing the day's proceedings to a close. The officer, as a rule, takes his observations while supper is being prepared, and before lying down winds up his chronometer and writes his journal. A very good rule is to give directions, for precaution's sake, that the tent-robe is never to be spread until the question has been asked, "Has the chronometer been wound up?" Before retiring, the cook sees every thing in readiness for the morrow's breakfast; the captain of the sledge serves out the breakfast allowance to him, and sees every thing connected with the sledge secure and safe.

The tent is made of light, close, unbleached duck, twelve square feet weighing a pound, lined with brown holland across the head, or end opposite the door, up to a height of three feet, and along the sides to a height of two feet. It is spread by means of tent-poles, two (crossed) at each end, and set up with tent-ropes or guys. A window, six inches square, is fitted at the upper end with a flap to trice up or haul down. There should also be a pocket at this end for the use of the officer, in which instruments, etc., might be placed. A cook's pocket at the opposite or door end of the tent is also convenient. In *very* severe weather the cooking has sometimes to be per-

formed inside the doorway; it is, however, very objectionable, and should not be practised more than is absolutely necessary, as the steam condensing covers every thing near it with fine particles of frozen vapor, and the soot from the stearine-lamp blackens every thing. The furniture for a tent consists first of a water-proof floor-cloth, made of a light description of mackintosh; this should be used with care, and only over snow. The coverlet should be made of the Hudson's Bay three-point blanket or thick duffle, its upper side covered with glazed brown holland. Three stops should be sewn on one end of this coverlet, for tying it when rolled up, and when in use for tying it to the lower robe at the upper end or head of the tent. The knapsack forms the pillow.

The canvas floor-cloth, though not absolutely indispensable, is, however, very useful. It is made of very light unbleached duck, and is also used as the sledge-sail, which is only set when the wind is abaft the beam. It should be laid down over the water-proof floor-cloth, when the men are taking off their boots and taking their suppers. In severe weather, when the breath condenses in the tent and falls in minute frozen particles, the canvas floor-cloth is useful to spread "over all" after the men have laid down, as it catches all this fine snow, which would otherwise penetrate into the coverlet, where it would thaw by the heat from the men's bodies, and be frozen into them again when exposed to the air. "So rapidly," says Sir Leopold McClintock, "does frost accumulate, that in eighteen days of traveling during the month of October I have known the coverlet and the lower robe to become more than double their original weight."

The lower robe or blanket should be of the same material as the coverlet, namely, three-point Hudson's Bay blanket or thick duffle. It should have a covering of brown holland on its underneath side, having stops on its upper side to tie to similar stops on the coverlet when spread for the night: probable weight of the lower robe about seventeen pounds. This robe has sometimes been of fur, but it has its disadvantages, as in the first place it is more absorbent; a skin will when wet emit a disagreeable smell; the hairs come out, and they shrink very much; they are also more stiff and unmanageable when frozen. The above-mentioned woolen materials are on the whole preferable, as they are quite as warm as fur, when covered with the brown holland, in addition to which evaporation from the body will generally make its way through woolens, and escape into the air, but in the fur robe is arrested and condenses in it. The coverlet, lower robe, and sleeping-bag, answer well when the temperature is no lower than — 30°, but should it fall lower, an additional coverlet should be supplied, as well as a small blanket bag to put into the sleeping-bag to keep the feet warm. Should the temperature continue to fall, snow huts should be used, they being very much better and warmer than tents. A party of four men can, after a little practice, hut themselves

in about half an hour; one man cuts the blocks, another builds, and the other two carry the blocks and fill up chinks, etc.

Building a hut with a large party, however, is a different matter, the difficulty in constructing the dome greatly increasing as its diameter is enlarged. It then becomes a question whether it would not be more advisable to build two huts, and to divide the tent-robes, etc., between them, or to build four walls inclosing a space of about six and a half feet wide, and long enough to accommodate the whole party (fourteen inches being the allotted space of each man). The tent is then used as a roof, by being laid over the walls, and snow thrown on it to prevent the wind blowing it off. The walls should incline inward slightly, and be about five feet high, and the floor excavated to a foot or so to give additional height inside. The advantages a snow hut has over a tent-roofed house is, that should the temperature become high, the moisture overhead runs down the walls in the former, whereas in the latter it drips, and makes the tent so wet that when it freezes again it is almost impossible to spread it. The snow hut which Englishmen should construct (that is, without the aid of the Esquimaux) is made of slabs of caked snow about two feet long, one wide, and six inches thick. The site (a circle) is first marked out on the snow, and beginning with a very narrow slab, inclining slightly inward, the building is commenced and continued spirally, until at a height of about five feet, when a single rounded slab is cut, closing up the centre of the dome. The entrance is as low as possible, and is cut the last thing by the man inside. When the temperature is low it will be found preferable to encamp on snow rather than on land, and still warmer upon ice when there is water underneath, which will materially add to the warmth and comfort of the encampment.

While dragging the sledges it is very necessary to keep continually changing the leading men on the drag-ropes, as on them rests the severe task of exerting their eyes in order to pick their road, and they are therefore more subject to snow-blindness than the others. The officer, when not engaged in dragging the sledge, should be very particular in selecting a good and easy line of country; this is of the utmost importance.

We will now suppose that the season for sledge-traveling has passed, the sun no longer sinks below the horizon, the object for which the sledge-parties have been striving has been gained, and they have all returned to their ship, which they left three months before frozen up in the solitude of their winter quarters. Some, which have returned early, after taking out depots for the extended parties, have since been actively engaged on regularly-organized shooting-excursions. But all are back by July. They return to a busy scene. Active preparations are being made to get the ship ready for sea. The housing is taken down and stowed away below, and it is to be hoped will not again be seen, as rumor whispers they are homeward bound;

spars are swayed up and sails bent, and the ship is again "all a taunto," and all are anxious once more to feel the long roll of the ocean. The open water is seen to the southward from the crow's-nest, but it is some distance off, and the ship is held fast in the wintry grasp of the ice. The month of June has come and gone, July is nearly at an end; if they are not shortly released, they will perhaps be doomed to spend another winter in that inhospitable and inclement region. During the preceding months those on board have not been idle, as a long line of ashes, sand, and rubbish of all descriptions, thinly sprinkled from the ship's bows in a long straight line to the southward, will testify. This has been done with the object of penetrating and rotting the ice, the dark color attracting the heat of the sun, so as to make a passage for the ship to pass through. This device has failed, and others must be resorted to to effect their liberation.

Blasting has been determined upon. Charges of three pounds, five pounds, and ten pounds of ordinary gunpowder will be prepared for use, in tin canisters, with Bickford's fuse. If, however, the new explosive "cotton gunpowder" should be the substance selected to carry out this object, a small charge of about two pounds is prepared, primed with its detonator, to which is attached a short length of Bickford's fuse. Operations are commenced from the open water and carried on toward the ship. A hole is made in the ice by means of a drill some distance from its edge, and the charge is lowered down through this until it reaches the water and is placed immediately under the ice. The fuse is ignited, a sharp explosion takes place, and the ice is shattered and rent in all directions. Men in boats, and others armed with boat-hooks and long poles, at once assail the fragments, removing them from the channel into the open water. These operations are repeated until a clear channel has been made, through which the ship is able to steam and thus effect her escape. The advantages which the "cotton gunpowder" has over ordinary black gunpowder are numerous. It is a much more powerful explosive, its proportionate strength to common powder being as eight to one, but its great merit is said to consist in its perfect safety. If put into the fire it will burn quietly, without any explosion, nor will it explode on concussion.

The practice of ice-blasting is not a new invention, and had been much resorted to by the various search expeditions. Their plan was simply to lower a glass bottle, or preserved meat tin, containing from two to four pounds of ordinary gunpowder below the ice, and explode it. The results were most satisfactory. Lieutenant Mecham tells us that during Captain Austin's expedition, in 1851, a blasting-party was employed for twelve days in detaching a floe from the eastern shore of Griffith Island. With 216 pounds of powder they cleared away a space 20,000 yards in length, and averaging 400 yards in breadth; this ice varied from three to five feet in thickness. The estimated weight of the ice removed was about 216,168 tons. The heaviest

charge used on this occasion was sixteen pounds, lowered ten feet below five-feet ice; its effect was the breaking up of a space of 400 yards square, besides splitting the ice in several directions. The last charge would be equivalent to two pounds of "cotton gunpowder," but the results with the latter explosive would, in all probability, be far more effective.

The work of an exploring expedition in the arctic regions for the period of twelve months has now been detailed. No unforeseen accident, no detention in the ice, in fact no casualty of any description has been taken into consideration, but every thing has progressed under the most exceptionally favorable circumstances. That the same will be the case with the Arctic Expedition of 1875 is too much to expect, but that it will be successful in exploring a large area of unknown land may be confidently hoped and anticipated.—*Geographical Magazine.*

DISTRIBUTION OF ATMOSPHERIC MOISTURE.

ALL over the earth, the more largely where its beams reach the surface with the least diminution of heat, the sun is continually engaged in evaporating moisture from all exposed surfaces of water; this remains suspended in the atmosphere, and is carried about by the winds in the form of impalpable vapor or of clouds, till the point of saturation is reached, and the moisture falls again to the earth's surface in the form of rain, or snow, or hail. Air becomes lighter, and consequently expands and ascends, when it grows hotter, and becomes heavier and falls with cold. The hotter it is the more moisture it is able to hold in solution. Between the equator and the poles there is a difference of 80° of average annual temperature. In the torrid zone the light, warm, vapor-laden air is ascending continually to the upper regions of the atmosphere, and there flowing outward north and south toward the poles, and the cold, heavy air from the polar regions comes rushing along the surface to fill its place. As the seasons change, the line of the greatest heat in the world gradually moves its position. At the equinoxes of spring and autumn it runs along the actual equator, or near it. In winter it lies south of the earth's equator, about midway between the equator and tropic of Capricorn. Not more than half as much of the tropic of Capricorn as of the tropic of Cancer runs over land, and this makes a material difference, because the more sea the more the intense heat is deadened and absorbed. In summer the great continental area traversed by the tropic of Cancer, a long line of which is removed from the ameliorating influence of the sea, becomes excessively heated, and from the great African Sahara, through Nubia and Arabia to the north of India, runs a tract of intense heat, in which the July average in the shade rises to 90°.

ZONE OF PERIODIC WINDS AND RAINS.—It is to this changing line of the greatest heat that the main currents of wind are directed. Within a zone extending for about 30° on each side of the equator the winds blow with great regularity. When they leave the polar regions the tendency of the surface-currents is due north and south, but in their course they become deflected longitudinally in consequence of the earth's motion, and reach the line of greatest heat as northeast and southeast currents. The tropic of Capricorn has its air rarefied by heat in our winter, and this produces within the torrid zone what is called the northeast trade-wind or monsoon. The tropic of Cancer has its air still more rarefied by heat in our summer, and this produces the south monsoon. Through these causes this central belt of the world has its winds and rains perfectly steady and regular, and within it there falls the greatest quantity of rain which there is in any part of the world. The rainy season begins some time before the sun reaches the zenith of a place, and continues for some time afterward. In a belt near the equator there are two rainy seasons, the main one, which lasts three or four months, beginning when the sun, in its progress to a vertical position, has crossed the equator, and a shorter one, which lasts four or six weeks, when the sun is coming again from the tropic to the equator. Nearer the two tropics the countries have only one rainy season, which begins when the sun approaches the tropic, and one dry season, the year being divided between the two. The rain pours down in torrents in a way of which we can form no notion from our experience in temperate countries. Our London rainfall is 2 inches a month, but in the tropics an inch a day is not an uncommon average for the whole rainy season. On the banks of the Rio Negro Humboldt collected as an ordinary rain 1¾ inch in five hours. In Cayenne Admiral Roussin collected, between the 1st and 24th of February, 12½ feet, and in one night, between 8 P. M. and 9 A. M., measured 10¼ inches. In the Himalayas of Khasia as much as 600 inches are said to fall in a single year. The rain, however, does not commonly pour down without intermission night and day, and day after day, as is sometimes the case in the English lake country. The ordinary succession of atmospheric phenomena is as follows: The sun rises in a cloudless sky. Toward noon some faint clouds appear on the horizon, which increase rapidly in density and extent, and are soon followed by thunder and violent gusts of wind, accompanied by heavy rains. Toward evening the rain abates, the clouds disappear, the sun sets in a serene sky, and during the night no rain falls. The annual quantity of rain which falls upon any particular place depends greatly upon local circumstances, just as it does in the temperate zones, and is greatest where hill-ridges are placed so as to catch the clouds, and smallest in tracts that lie to landward of such ridges. To take our illustrations from India, where the south monsoon blows laden with the copious vapors raised by the equatorial

sun from the broad expanse of the Indian Ocean, we find that in the eastern Himalayas the rainfall varies from 200 to 600 inches a year, and that at Mahabaleshwar, where the clouds drift against the high ridge that lines the west side of the peninsula, it is 248 inches, but that at Courtallum it is only 40 inches, at Bangalore 35 inches, at Cape Comorin 30 inches, and at Bellary in Mysore 22 inches, which is as low as in any part of England.

Zone of Periodic Winds without Rain.—Outside the zone of periodic winds and rains comes a double belt, one girdling the world in the northern, and the other in the southern hemisphere, the breadth and area of which are greatly modified by local circumstances, within which no rain ever falls. These belts are estimated to include altogether an area of 5,000,000 square miles, but it is impossible to make any calculation that is at all precise, because round the tracts that are entirely rainless are regions in which rain falls but rarely, which again pass gradually into the two rainy zones, through countries like Southern Palestine and the Gangetic plain, which, though usually rainy, are liable at intervals to years of drought. These belts of rainless land near the tropics contain some of the most hopelessly dreary country which the world can show. Beginning with the west of the old continent, we have along the tropic of Cancer in Africa the Sahara or great desert, on the southern border of which the rains cease at 16° north latitude, and begin again on the north at 28°. Passing farther east, the southern rains cease in the countries on the banks of the Nile between 18° and 19°, and the northern begin between 27° and 28°. Passing into Asia, there is a great rainless tract in Arabia of which we do not know the exact bounds, and it reaches through Beloochistan over into the delta of the Indus, where it does not cover more than 4° of latitude. From this point the rainless zone turns to the northeast and extends to 30° north latitude. Crossing the great Himalayan chain it includes the high table-land of Thibet, but does not appear to reach into the Chinese Empire. In South Africa there is a sandy, desert, rainless tract on the north of the Orange River, between 24° and 28° south latitude, and a great part of the interior of Australia seems to be nearly or quite rainless. In North America the rainless belt includes the Californian peninsula, and extends round the northern end of the Sierra Madre chain past Chihuahua and Monterey to the shores of the Gulf of Mexico between latitudes 24° and 26°. In South America it includes between latitudes 23° and 27° the northern province of Chili, and, through an extensive low tract in the interior of the continent belonging to the territory of the Argentine Confederation, rain is very unfrequent and small in quantity.

Zone of Variable Winds and Rains.—From about latitude 30° on each side of the equator to the poles extends a region of ever-changing and variable winds, and of rain that is irregularly distributed throughout the whole year. Sometimes in these middle lati-

tudes, in Britain, for instance, we fall within the sway of the south-rushing polar current deflected to the east by the earth's rotation, and sometimes within that of the north-rushing current from the equator, deflected to the west by the rotation which it shared with the earth at the zone from which it started. In Britain this southwest wind comes to us laden with vapor from the great mass of the Atlantic, and makes Ireland and our western shores unusually damp and rainy. The relative temperatures of sea and land in the temperate zones are continually changing with the seasons. In summer and autumn the Atlantic is colder than the European Continent, and this has a tendency to produce a west current at the surface. In winter and spring the Atlantic is warmer than the continent, and this has a tendency to produce an east wind. Sometimes one of these varying tendencies gains the predominance and sometimes another, and the result is constant and often rapid change and variety. The heat and moisture which the wind brings with it depend entirely upon where it comes from, and what it has passed in its way. A west wind blows to us from the Atlantic, and usually brings rain; an east wind brings up the fog of the German Ocean; and in winter and spring the prevalent northeaster brings the cold and often the snow of Russia and Norway. At the sea-side, unless it be overpowered by a general current, there is a breeze from off the sea during the day, and a breeze from off the land during the night. The quantity of rain that falls in this zone at different points is extremely variable, and depends upon the position of a place with regard to mountain-masses and the seas from which the vapors come. In England the rainfall is greatest on the west side of the island, and smallest on the east. The difference within a short distance is sometimes very striking. There are 140 inches a year at Borrowdale, in the lake district, and not more than 20 inches at Shields and Sunderland, which are directly opposite on the east coast. But the habitual humidity of the atmosphere often varies but little between places the rainfall of which is very different. The number of days upon which more or less rain falls, varies in England from 100 to 300, but in the Mediterranean region the number of days is fewer, the quantity is smaller, and there is an almost regular period of entirely dry weather in summer. Taking the north temperate zone as a whole, there is, as a rule, least rain in places away from hills in the interior of continents, and most in insular and mountainous situations.—*Gardener's Chronicle.*

CORRESPONDENCE.

SCIENCE AND THE BOOK OF GENESIS.

To the Editor of the Popular Science Monthly:

I HAVE been an attentive reader of THE POPULAR SCIENCE MONTHLY for over two years, and in that time not one article, editorial, or note of correspondence, has escaped my notice. Also, I have been deeply interested from the first in all the advanced positions of the MONTHLY, and have noted its strictures on the narrow intolerance and ignorance of the clergy, and the many hints that they should enlarge the field of their observation and knowledge; and I am convinced that many of these hints are well-timed. But, then, ought not men of science also to be more liberal and better acquainted with biblical knowledge? The theologian observes in the writings of men of science the same narrowness and ignorance of the Bible that the scientist sees in the writings of theologians concerning his particular line of study and investigation.

In No. XXXVII. of THE POPULAR SCIENCE MONTHLY, the editor says, in his notice of Dean Stanley's sermon on the death of Sir Charles Lyell: "Dean Stanley is far from being alone in his views; they are shared by many other eminent clergymen who recognize that the Mosaic account of creation is without authority." But, does Dean Stanley indeed "recognize that the Mosaic account of creation is without authority?" Be that as it may, ought not any man to lose the respect of his fellowmen who will consent to remain a clergyman, and yet reject the authority of the Bible?

Certainly no particular account of creation was intended by the author of the Book of Genesis—nothing more than a brief outline, and he gives no intimation as to the time when this world began to be. Nor is there any reason why the six days of creation should not be regarded as so many general periods, without any limitation as to duration. But, if you will carefully notice the statements of Moses, you will find some things hard for the scientist to dispose of, if the account of creation is without authority. Moses says: "In the beginning the earth was without form and void." Does not the scientist say substantially the same thing?

Then take the different stages in the progress of the world, as stated by Moses, and especially as to the appearance of life; do they not agree perfectly with the revelations of science? Moses says the first life was vegetable—grass, herb, tree. Next came a low form of aquatic animal life—"the moving creature that hath life"—developing into fishes and fowls of the air. Then land-animals, and, lastly, man appeared on the earth. Now, what says modern science of this arrangement? Does it not fully sustain this Mosaic account of creation? Even the modern doctrine of evolution—Darwinism, if you please—is as nearly taught in the first chapter of Genesis as in the revelations of modern science; and spontaneous generation seems to appear on the very face of the statements of Moses as therein recorded. Read verses 20 and 24: "And God said, Let the *waters bring forth abundantly*," etc., "And God said, Let the *earth bring forth*," etc. And as for man, if God saw fit to straighten up a monkey and endow him with human reason, whether that took the Almighty one hour or a thousand years, who need object? It is certain that it can be proved neither by the Bible nor modern science, either that God did or did not make man in that way.

But here comes the question as to the authority of the Mosaic account of creation: How was the author of that account able to state in so brief a space the main points in the earth's development, just as they are now known by the revelations of science, when he wrote at least three thousand years before the sciences which have now brought these things to light were born? Was Moses a profound scientist?

or did he write under the influence of divine inspiration?

Rev. J. C. MAHIN.

PERU, INDIANA, *June* 21, 1875.

THE MECHANICAL POWER OF LIGHTNING.

To the Editor of the Popular Science Monthly:

IN the afternoon of June 26, 1874, a thunder-storm passed over the town of Cummington, Hampshire County, Massachusetts, during which an exhibition of the mechanical power of lightning was displayed, which I believe is extremely rare, at least in this latitude.

A sugar-maple tree (*Acer saccharinum*), thirteen feet in circumference four feet from the ground, was struck, and split in several places, apparently throughout its diameter, from the ground to a height varying from twelve to twenty feet. On reaching the earth, the main portion of the shaft passed to a piece of wet ground several rods distant, in its way ploughing a furrow from one to over three feet in depth, tearing seven trees, the largest six inches in diameter, from the ground, and throwing them several feet from their former places. A rock containing thirty-six cubic feet was torn from its bed, and rests on the surface, three feet from its original position. In its course it passed under another maple, two feet in diameter. The tree was not thrown down, but the earth was thrown up from beneath its roots, in places, to the depth of three feet. This tree stood about sixty feet from the one struck. It then passed thirty or forty feet farther, through earth so wet in some places that the trench made by it filled with water. After making a cut eight feet wide at the surface, and three feet deep through a knoll, it divided, and, after passing a short distance farther, struck at three points a half-inch lead water-pipe, running at right angles with its centre, filled with water at the time, and covered with about two feet of wet earth, which was thrown out, and the pipe destroyed for a distance of 200 feet. No trace of the pipe could be found in many places, excepting scattered gray oxide of lead. In its way from the tree to the pipe, large masses of mica-slate rock were shattered, and one observer saw large stones which were thrown above the top of the surrounding trees.

Nearly the whole distance traversed by the lightning was woodland, and the soil was firmly bound together by interlacing roots; many of these, large enough to resist the power of the strongest yoke of oxen, were snapped like pipe-stems, the fracture being almost as smooth as if cut with a saw. Lighter portions of the electricity radiated in various directions from the tree, turning up the earth like a plough, for a distance of from 40 to 100 feet. The tree was struck while the rain-cloud was at least two or three miles distant. Many people were out, making preparation for the coming shower at the time, and the bolt was seen by several persons as it darted from the coming cloud. I visited the place nearly a year after the event, but all that I have described is yet visible. I can only account for this tremendous force by supposing that the water in the soil, converted instantly to steam, produced these results.

DEWEY A. COBB.

PROVIDENCE, R. I., *June*, 1875.

EDITOR'S TABLE.

RELATIVITY OF TRUTH.

AMONG the higher influences of science to be realized in the future, will be its inculcation of more correct views concerning the relation of the human mind to truth. The effect of partisanship in politics and theology—the two great schools in which people are chiefly educated—is to establish the idea that truth is something absolute, that can be got once for all, and then can be comfortably held and professed forever afterward. There are only truth and its opposite error sharply divided off to choose from; and a "yes" or "no" is demanded for all propositions. In some things this is no doubt true; there is only one side to the multiplication-table.

But, in extensive divisions of thought, truth is only a relative thing; of inestimable value for its time, and most of all valuable as a means of getting away from it and attaining more perfect truth. Logic is the art or science of arriving at truth by ratiocination; but science is the field where logic is put to practical application and subjected to the most rigorous tests. The human mind if left to logic alone may go wild in any direction; science holds it steadily to the observed order of Nature as the standard by which it is to be tried. The whole circle of the sciences bears witness to the correctness of scientific thinking; and the history of every science abounds in proofs of the relativity of truth. Certain parts of elementary facts may remain constant, but even the interpretations of these, true only for their time, are changed, age after age. The science of chemistry affords an admirable exemplification of this view.

There was vague and indefinite truth even in the chimeras of the alchemists, mixed indeed with an enormous amount of gross error and preposterous speculation as seen from subsequent points of view; but there was sufficient of verity and correspondence to reality in those mystical times to guide men to important discoveries. The alchemists found out a great number of new and valuable things. They worked under delusions, but these were far from being destitute of plausibility; and were in fact in no small measure consistent and rational. Experimental knowledge at any rate grew in extent, and somewhat in coherency, until the absurdities of the epoch fell away and a definite and rational chemical system ensued.

This was the epoch of *Phlogiston*, which was held to be a kind of subtile matter or energetic essence, present in all combustible bodies and absent in all incombustible bodies, and which caused combustion-changes in its escape. It was a theory of the nature and cause of fire; and, as heat is implicated in nearly all chemical changes, it was a crude theory of chemical action. It served the most important uses. It was a principle of connection and association, and explication, which stimulated investigation, guided inquiry, and enlarged the domain of actual knowledge. A chemical belief that the discoverer of oxygen, Dr. Priestley, held to the day of his death, could certainly not have been an absurdity. Prof. Cooke has the following excellent remarks on this early theory: "That it was not absurd a single consideration will show. Translate the word *phlogiston*, *energy*, and in Stahl's work on chemistry and physics, of 1731, put *energy* where he wrote *phlogiston*, and you will find there the germs of our great modern doctrine of conservation of energy—one of the noblest products of human thought. It was not a mere fanciful speculation which ruled the scientific thought of Europe for a century and a half. It was a really grand generalization; but the generalization was given to the world clothed in such a material garb that it has required two centuries to unwrap the truth." Nevertheless there was invaluable truth in it, but truth obscured, imperfect, and in relation to the time.

The phlogistic doctrine broke down as the facts accumulated and outgrew it; and chemical science passed into a new phase. That which had long helped at length became an obstruction, and, with the abandonment of the entity, chemical effects began to be referred to inherent attractions among different kinds of matter. But the facts must still be interpreted by principles or theories, and, at the epoch of Lavoisier, affinity, or the energy of chemical change, was viewed simply as a coupling force. Combination and decomposition were supposed to take place directly among bodies in pairs; elements uniting with elements to form binary compounds, and these uniting again by twos to form

double binary or ternary compounds, and when these were made to act on each other the reaction was represented as a double decomposition. This was known as the dual theory of chemistry, and it organized and explained the facts of the science in the most beautiful manner. Electro-chemistry lent it powerful aid, as compounds were resolved into pairs by galvanic decomposition, and their elements were supposed to be in opposite electrical states and to be united by polar attractions. The atomic theory gave a basis of philosophy to the doctrine, and the admirable nomenclature which was adapted to it gave it wide currency and acceptance. Under this chemical system the science grew and flourished for more than half a century, spread out into branches, and became the guide in medicine, mining, agriculture, and numberless arts and manufactures. Yet this system, too, was true for its time; only true in relation to the facts known, and is now doomed to the fate of phlogiston. As it grew out of a preceding stage upon which it was a great improvement, so it has led to a subsequent and higher stage of knowledge, to which it must in turn give way. Its facts live on; its partial truths survive and are expanded into new forms, and a system of doctrine has arisen so contrasted with the dual theory and so advanced beyond it that it is now characterized as the "new chemistry" in contradistinction to the old which it has superseded. We are now entering upon the new chemical epoch in which ideas that have long simmered in the brains of chemists, and were long contested, have emerged into distinctness and are passing into predominance. The simple splitting and pairing theory of chemical change has failed, and we are becoming familiar with the conception of unitary structure, molecular types, and transformations by substitution and replacement that leave the construction and character of chemical compounds unaltered. The dualist appealed to analysis, and asked only what are the constituents and what their proportions in chemical substances. The apostles of the new chemistry point to the failures of analysis, and aver that it is not so much what a compound is made of, as how its elements are arranged, that is the present concern of inquiry. And chemistry was probably never so active as now under guidance of the new theories, and never before answered so well to that highest test of science, the prevision and prediction of chemical results. There is no escape from the new chemistry. It absorbs the verities of the past and it is the highest truth arrived at by centuries of thought and labor. But it is not a finality. Its truth, though priceless, is imperfect, and is no doubt destined to still further and higher development. Historically regarded, the science of chemistry is a striking exemplification of the laws of mental evolution, as the doctrine of evolution is the grandest illustration of the relativity of truth.

An interesting illustration of the striking changes of view that have taken place in modern chemistry is furnished by the reversal of scientific rank assigned to those prime elements of Nature, oxygen and hydrogen gases. Oxygen was long enthroned both from its enormous distribution in earth, sea, and air, and its active participation in the great changes of matter, combustion, respiration, decay, all of which were generalized as different forms and grades of *oxidation*. It was supposed to be the acidifying principle in Nature, and was early taken as a standard in chemical scales. Hydrogen was also known as a widely-diffused and important element, but of far inferior import to oxygen, and received its name from the fact that it generates water by union with oxygen. But, as more was known about it, it was found to be deeply im-

plicated in the universal transformations of matter. It turned out that hydrogen not oxygen is the great acidifying principle, and not only so, but it is the base-producing principle, while the old and antagonizing classes of acids and bases disappeared as separate groups and were merged in one great division of hydrates. Hydrogen, moreover, by its remarkable properties and position has become the unit and standard of the modern chemical system, and, though less abundant upon earth than oxygen, it is the grand element of the sun, has been detected in the remotest stellar luminaries, in the mysterious nebulæ, and blazed out in a mighty conflagration of one of the most distant stars. Such is the part played by that form of matter which is the most attenuated, ethereal, and "nearest to nothing," of any we know.

LITERARY NOTICES.

THE PRINCIPLES OF SOCIOLOGY. By HERBERT SPENCER. A Quarterly Serial. Part III. D. Appleton & Co. Price, $2.00 a year.

IT is an essential part of Mr. Spencer's method of treating sociological science to trace the genesis of the fundamental ideas which have become embodied in social institutions. The installment of his work now before us is devoted to the origin and development of religious ideas. These have been powerful in all ages, in all places, and in all grades of society, in influencing human conduct, and in determining the constitution of the social state. In this country religion is largely differentiated from government; but it remains at the basis of extensive and important institutions. In European nations, and in most countries in fact all over the world, religious establishments are still part of the state organization and potent factors in determining the structure of society. An element of the social state, so universal and pertaining to humanity itself, is certainly a fit subject for scientific elucidation. For, although it is claimed in special cases that religious ideas are not of natural but of supernatural origin, and therefore not amenable to the scientific method of investigation, yet those who entertain this view always limit it to a particular case. The believers in the supernatural origin of religious conceptions generally restrict their view to the one religion which they hold to be true. But, although the implication is that all other religions are false, they still remain to be accounted for, so that, admitting the supernatural character and origin of a single system of faith, there yet remain hundreds of other systems of all complexions and gradations which are the legitimate subjects of study from the scientific point of view. A Christian may hold his system to be preternaturally given, and its origin to be not open to scientific scrutiny or criticism; but he cannot object to the employment of science in tracing out the development of religious notions among heathen and savages. There is, therefore, plenty of legitimate room to carry on the inquiry.

In this number of his work Mr. Spencer devotes himself to tracing the origin and growth of religious ideas, that in their various forms may be regarded as universal. His aim is to show that they are natural and necessary outgrowths of the intercourse with Nature of the human mind before it has learned any thing of the true order of Nature. In his successive chapters he treats of "The Ideas of Death and Resurrection," "The Ideas of Souls, Ghosts, Spirits, Demons, etc.," "The Ideas of another Life," "The Ideas of another World," "The Ideas of Supernatural Agents." The argument, as is usual with Mr. Spencer, is able, the analysis clear, and the presentation forcible. The work is full of fresh and interesting information regarding the mental states and habits of the lower races of mankind, and the accompanying psychological discussion gives an impressive interest to the facts.

TRANSITS OF VENUS. A Popular Account of Past and Coming Transits from the first observed by Horrocks, 1639, to the Transits of 2012. By RICHARD A. PROCTOR. 232 pp., 12mo. New York: E. Worthington & Co.

THIS last book from Mr. Proctor's pen is written in his usual charming style, and, as the author says, is intended to be partly historical and partly explanatory. The

book opens with an account of the transits of the seventeenth century, when, as a consequence of the establishment of the Copernican theory of the solar system, astronomers perceived that the inferior planets, Mercury and Venus, must from time to time appear to cross the face of the sun. Kepler calculated and announced, in 1627, that in the year 1631 both Mercury and Venus would pass over the sun's face—Mercury on November 7th, and Venus on December 6th; and that in 1761 Venus would again pass across the face of the sun. As the first occasion on which the transit of an inferior planet was ever witnessed, the transit of Mercury in 1631 has an interest resembling that which attaches to the first observation of a transit of Venus, eight years later, the one contemporaneous with Mercury not having been observed, as it took place in the night-time; and, as to this one which took place eight years later, Kepler had calculated that, while in inferior conjunction December 4, 1639, Venus, though near the sun, would pass below its disk, and there would be no transit, which calculation happily was found to be a miscalculation, and therefore a transit would really occur. The first observation of a planet's transit, that of Mercury, was made by Gassendi, of Paris. Through a small aperture in a shutter the solar light was admitted into a darkened room, and an image of the sun, some nine or ten inches in diameter, was formed upon a white screen. A carefully divided circle was traced upon this screen, and the whole was so arranged that the image of the sun could be made to coincide exactly with the circle. As he had no trustworthy clock with which to ascertain exactly the moment of ingress, which he was anxious to do, he determined that the altitude of the sun should be carefully estimated during the progress of the transit. For this he needed an assistant, whom he placed, with a large quadrant, in a room above him, instructing him to observe the height of the sun as soon as he heard Gassendi stamp upon the floor of the room beneath. With these preparations Gassendi began to watch for the transit *two days* before its appointed time. To make a long story short, by the evening of November 7, 1831, the *first transit* had been observed, and in the manner here described. The first observed transit of Venus (to which planet Mr. Proctor gives his whole attention from this point) followed that of Mercury, and was calculated and observed by Horrocks, a young minister of Hoole, in Lancashire, who was a prodigy for his skill in astronomy. He was but twenty years old when he calculated this transit, and died two years afterward. He possessed a telescope, "the recent and admirable invention," which he used in the observation. The transit came on Sunday. He had watched two days, and Sunday until the hour for divine service. Returning from this at fifteen minutes past three in the afternoon, he found Venus just entered on the sun. Sunset cut him short with half an hour, but Venus had been seen in the act of transit. The transits of 1769, together with the methods suggested, during the interval since the last transit, for utilizing them in determining the solar parallax, are next dwelt on. A long and instructive chapter on transits and their conditions is then introduced, after which the subject of the coming transits is taken up. As the book was put to press just before the late transit, it is of course included among the latter.

THE UNSEEN UNIVERSE; or, PHYSICAL SPECULATIONS ON A FUTURE STATE. 212 pages. New York: Macmillan & Co. 1875. Price, $1. In paper, 60 cents.

WE briefly announced this work in the June MONTHLY. It has been for some time anticipated with an earnest interest by some, and a vague curiosity by others, as rumor made it the joint production of two eminent *savants;* and it was expected that a crushing double shot would be poured into—somebody. It has been since stated that the book is due to Prof. G. P. Tait, the eminent mathematician of Edinburgh, and Prof. Balfour Stewart, of Owens College, Manchester, author of various works on physics, among which is the little volume on the "Conservation of Energy," published in the "International Scientific Series." These are strong men; the subject is one of profound interest, and is certainly handled in an original way, and the volume, besides, is cheap, and in excellent type. The best analysis that we have

seen of the work, and a better one than we could prepare, appeared in *Nature*, and we shall best serve our readers by quoting freely from the review:

"The preliminary chapter states the fact of the all but universal belief in, or aspiration after, immortality. It admits that that doctrine is inconsistent with the doctrine of continuity as generally understood and as applied solely to the visible universe. It accepts and explains the principle of continuity in the fullest sense, and it attempts to reconcile it, as thus apprehended, with the doctrine of immortality. Incidentally—out of the apparent waste of energy in space, and on other indications chiefly teleological—it constructs an hypothesis of an invisible universe, perhaps developed out of another invisible universe, and so on *ad infinitum*. It is another consequence of the theory that our natural bodies are probably accompanied by a sort of invisible framework or spiritual body, and that the phosphorus and other substances of which the natural body is built up are not really identical with these elements in their ordinary condition of inorganic atoms, but are somehow transubstantiated by the coexistence, along with the mere chemical substance or with its chemical properties, of this invisible, imponderable, immaterial, accompanying essence, which derives a kind of *vis vivida* from a connection with the unseen universe. The passage from the visible universe to the invisible seems to be made intelligible to the authors by the existence of the ether, a substance into which energy is continually being passed, and into which it is perpetually, and, so far as any obvious or sensible effect is concerned, finally, absorbed.

"As a first postulate the authors assume the existence of a Creator. Finite beings, creatures, are conditioned by the laws of the universe, and it is in these conditions that we must seek to discover its nature. The first pair of subjects for human thought are matter and mind, and the materialists tell us that, whereas mind or mental activity never exists without being associated with some forms of matter, we may perfectly conceive matter, as for instance a block of wood or a bar of iron, existing without intelligence. Is mind, then, the dependent—is there nothing in matter which serves as the vehicle of intelligence different from all other matter? The authors answer that we have no right to assume that the brain consists of particles of phosphorus or carbon such as we know these substances chemically, that we cannot say that there may not be something superadded to their chemical and physical qualities. They dwell upon another fact—the fact that individual consciousness returns after sleep or trance; a fact inferring some continuous existence. The assumptions of the materialist are less inevitable than he supposes. Turning to mind, finite conditioned intelligence, the authors ask, what is essential to it? It must have some organ by which it can have a hold upon the past, and such a frame and such a universe as supply the means of activity in the present. Outside they find physical laws, and they look on the principle of continuity as something like a physical axiom. By this principle we are compelled to believe that the Supreme Governor of the universe will not put us to permanent intellectual confusion. It is in the nature of man, certainly in the nature of scientific man, to carry the explanation of every thing back *ad infinitum*, and to refuse perpetually to grant what is perpetually demanded of him, that he has arrived at the inexplicable and unconditioned. On this principle scientific men have supposed themselves to prove that the physical universe must one day become mere dead matter. The authors consider that this is a monstrous supposition, although they grant that the *visible*, or by-sense-perceivable universe, *must in transformable energy, and probably in matter*, come to an end. They think that the principle of continuity itself demands a continuance of the universe, and they are driven to believe in something beyond that which is visible as the only means of explaining how this system of things can endure in the future, or can have endured forever in the past. They see a visible universe, finite in extent and finite in duration, beyond which, on both sides stretching infinitely forward and infinitely backward, there is an invisible, its forerunner and its continuation. It is natural to infer that these two invisibles must meet across the existing finite visible universe. As we are driven to admit the invisible in the past and in the future, there must be an invisible framework of things accompanying us in the present.

"What, then, is this present visible universe; and can we point to sure signs of this invisible substance which accompanies what may prove after all to be the mere shadow of things? Matter has two qualities. The first is that it is indestructible; the second, that the senses of all men alike point to the same quantity, quality, and col-

location of it. Our practical working certainty of the existence of matter means: 1. That it offers resistance to our imagination and our will; and, 2. That it offers absolute resistance to all attempts to change its quantity. Certain other things—notably energy—are in the same sense conserved, and, if we recognize the transmutability of energy of motion into energy of position, we may say that energy is equally indestructible with matter itself. But energy is undergoing a perpetual self-degradation. All other forms of energy are slowly passing into invisible heat-motions, and when the heat of the universe has ultimately been equalized, as it must be, all possibility of physical action or of work will have departed. Mechanical effort cannot longer be obtained from it. The perfect heat-engine only converts a portion of the heat into work; the rest is lost forever as an available source of work. There is indeed a sort of wild and far-off possibility by which a little more work *might* be got out of a uniform-temperature universe, if we could suppose Clerk-Maxwell's demons—'mere guidance applied by human intelligence'—occupied in separating those particles of a heated gas which are moving faster than the average from those which are moving slower. But this is but a broken reed to trust, and it would at the best avail us little. What must happen in the existing physical system would be this: the earth, the planets, the sun, the stars, are gradually cooling; but infinitely numerous catastrophes, by which the enormous existing store of energy of position may be drawn upon, may over and over again restore unequal temperature. The fall together, from the distance of Sirius, of the sun and another equal sun would supply the former with at least thirty times as much energy as can have been obtained by the condensation of his materials out of a practically infinite nebulous mass of stones or dust. But these catastrophes can only delay the inevitable. If the existing physical universe be finite—and the authors never seem to realize the speculative possibility that it may not be so—the end must come, unless there be an invisible universe to supplement and continue it.

"What is the ultimate nature of matter, and especially of the ether, which is the vehicle of all the energy we receive from the sun? There have been four theories, for each of which something may be said. There is the Lucretian theory of an original, indivisible, infinitely hard atom, 'strong in solid singleness;' Boscovich's theory that the atom or unit is a mere centre of force; the theory that matter, instead of being atomic, is infinitely divisible, practically continuous, intensely heterogeneous; and, finally, the theory of the vortex-atom, a thing not infinitely hard and therefore indivisible, but infinitely mobile, so that it escapes all force which makes effort to divide it. What we call matter may thus consist of the rotating portions of a perfect fluid, which continuously fills space. Should this fluid exist, there must be a creative act for the destruction or production of the smallest portion of matter. Whichever of these theories we adopt, we must explain the simplest affection of matter—that by which it attracts other matter. There seems little possibility of doing so. The most plausible explanation is in Le Sage's assumption of *ultramundane corpuscles*, infinite in number, excessively small in size, flying about with enormous velocities in all directions. These particles must move with perfect freedom among the particles of ordinary matter, and if they do so we can understand how, through the existence of the ultramundane particles, two mundane particles attract inversely as the square of the distance. On this theory the energy of position is only the energy of motion of ultramundane and invisible particles—and a bridge is built between the seen and the unseen. These ultramundane particles are something far more completely removed from all possibility of sensible qualities than the ether which Sir William Thomson has attempted to weigh. Struve has speculated upon the possibility that it is not infinitely transparent to light, and his calculations, based on the numbers of stars of each visible magnitude, lead him to suppose that some portion of the light and energy from distant suns and planets may be absorbed in it. The ether is thus a kind of adumbration or foretaste of the invisible world. It may have certain of the properties of that world which is perceived by sense, but it is probably subject only to a few of the physical conditions of ordinary matter.

"Let us look once more at the substance of the universe. We recognize that it is impossible to suppose any existing state but as the development of something preëxisting. To suppose creation is to suppose the unconditioned. Creation belongs to eternity, and not to time. This being so, it is difficult to believe in the vortex-ring theory, which regards the invisible universe as an absolutely perfect fluid. With an imperfect

fluid, the eternity of visible matter which the vortex theory requires, disappears. Such a visible universe would be as essentially ephemeral as a smoke-ring—so that we may accept it as possible, if not probable, that the visible universe may pass away—that it may bury its dead out of its sight. In its present state we have three forms of development—Chemical, or Stuff-Development, Globe-Development, and Life-Development. It is a question whether the ultimate atoms of chemists are really ultimate; whether some agent, like great heat, for instance, could not split them up into various groups of some primal substance like hydrogen. We see the prospect of a similar simplicity in the development of worlds on the theory of Kant and Laplace, which makes the systems of the universe the result of the gradual condensation of nebulous masses. In the end, all the masses of the universe must fall together—in the beginning there can have been no masses, every thing being nebulous and discrete, even if ordinary matter be indestructible. The last state and the first state of the visible universe are thus separated from each other by a finite duration. A like simplicity may be reached in the development of life. Darwin has made it at least possible that all life may issue from some primordial life-germ. The complete refutation of the doctrine of abiogenesis—the practical proof that life issues only from life—leaves us still bound to account for that germ. There is no doubt that species develop varieties which may ultimately become distinct species, although there is little indication that the varieties of what was once one species are ever separated like species originally different, by a barrier of mutual infertility. A sufficient length of time might enable us to overcome this barrier. In all our developments—the substance-development, the globe-development, the life-development—we are thus brought, in the end, to a something which we are not yet able to comprehend.

"Turning from matter to the phenomena which affect it, we notice one singular set of phenomena in which things insignificant and obscure give rise to great lines of events. A whole mass of water, the temperature of which has been reduced below the freezing-point, suddenly crystallizes on the slightest starting motion; a whole series of tremendous meteorological phenomena, such as hurricanes in the Indian Ocean, happen because certain positions of Mercury and Venus affect the sun's atmosphere, causing spots in his, and the condition of the sun affects the earth. Like the complicated series of effects which follow the pulling of the trigger of a gun, the effects are utterly disproportionate to their causes. Man is a machine of this unstable kind—some trivial change affecting the matter of the brain is all that is needed to set him in motion. May not other beings be capable of touching what we may call the hair-triggers of the universe? Whatever these agencies are, angels or ministering spirits, they certainly do not belong to the present visible universe. The writers examine the sacred records to confirm their speculations."

PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. Twenty-third Meeting, held at Hartford, Conn., August, 1874. Salem, 1875.

THIS is the annual volume of the American Association, and represents the results of the Hartford meeting in 1874. It opens with the address of the retiring president, Prof. J. Lovering, of Harvard College.

This is concerned with what is called "the great problem of the day," viz., "How to subject all physical phenomena to dynamical laws," and gives an abstract of the various theoretical views on "action at a distance," which, although brilliant, is not fully satisfying.

The practical moral enforced by the address seems to be one designed for American physicists; the moral is that, "unless our physicists are content to lag behind and gather up the crumbs which fall from the rich laboratories and studies of Europe, they must unite to delicate manipulation the power of mathematical analysis."

It is quite true that the mathematics are sadly neglected among us, and of this we have a striking confirmation in this very volume: the only mathematical paper in the whole book is one which demands forty-seven lines for itself, and this is a new demonstration of one of the theorems of Euclid. It is indeed true that our physicists, our scientific men generally, and above all our students, need to recognize, far more than they now do, the value of analysis as a means of research.

We must not forget, however, what in fact is pointed out in this very address, that the basis for mathematical analysis applied to physics must come from labo-

ratory experiments: and certainly in this respect America has little to fear from importations of "crumbs." The laboratories of the Stevens Institute of Technology, of the Lawrence Scientific School, of Columbia College, of the University of New York, and others, bear faithful witness to thorough work, and to real advances in the most delicate researches of physics. It must be remembered, too, that great works of analysis are not plenty in any country, and we think that the masterly works of Ferrel, on the theory of the tides, redeem America from reproach for 1874 at least.

The "Report of the Committee on the Preservation of Forests" follows, and from it we learn that this important subject is now before Congress in a proper form, and that we may reasonably hope for some action from that body.

The Association is divided into two sections, A and B, the first of "Mathematics, Physics, and Chemistry," the second of "Natural History," and we can judge of the attention given to the various subjects by noting the number of papers devoted to each.

Thus we find for *Mathematics*, one; for *Astronomy*, three; for *Physics*, eight; for *Chemistry*, eight; for *Statistics*, one. This completes the work of Section A. In the section of "Natural History" we find for *Geology*, eleven papers; for *Paleontology*, one; for *Botany*, four; for *Zoölogy*, twelve; for *Anthropology*, two.

It cannot fail to be noted that on the whole this volume of 378 pages is a decided improvement on its predecessor of 669 pages, particularly in the character of the publications printed. The printing committees seem to have exercised a careful scrutiny of the work put before them, and their selection has made the volume not uncreditable to American science.

We had not intended to notice in detail any of the separate papers, since they are all to be seen in the volume itself, and since very full reports of them were published by the *New York Tribune* during the time of the meeting; but it is impossible to avoid calling attention to a paragraph in a paper by Dr. Asa Gray, the great botanist of Cambridge, on the growth of the trunks of trees. The question was raised as to whether a tree in growing expanded its main trunk vertically in those parts once formed; experiments were made to determine this point by Dr. Gray, and the experiments and theories of various correspondents are analyzed by him. Of one he says:

[This] correspondent, "who has read in the older books on the structural botany a good deal more than there is any foundation for, about a collum, or collar, between the root and the stem, and who states that the wood is here of horizontal instead of vertical fibres, or cells, suggests that the trunks lengthen at their base only, and by the increase of these horizontal wood-fibres, formed one above the other, at the level of the ground. Now, in the first place, this supposed collar was only between the primary root and stem of a seedling; so that only trees raised from seed could be lengthened by its growth, not those originated from suckers, layers, or cuttings. Next, trunks lengthened in this way would come to have the butt-log composed of wood with horizontal fibres, which I think nobody ever saw. And, finally, there *is* no such collar, even in the seedling, with horizontal fibre, interposed between the root and stem."

We quote this to show that in some instances botany is more than an exact science—it is a precise one.

THE MAINTENANCE OF HEALTH. By J. MILNER FOTHERGILL, M. D. 366 pages. New York: G. P. Putnam's Sons, 1875. Price, $2.00.

THIS book is, in the author's first and last words, "a medical work for lay readers," "writ out of great good-will unto my countrymen." The book is divided into thirteen chapters, with the salient points summed up at the end of each in a list of propositions. The first chapter treats of health, what it is, and how maintained laying down many propositions, among which are that there are different types of health, and that bodily and mental health must go hand-in-hand. The next three chapters treat successively of health in youth, or the period of growth; health in adult life; and health in old age, or the period of decay. Chapter V. discusses the quality, quantity, and properties of food and clothes. Chapter VI. is given to stimulants and tobacco, in which the author uses these propositions: "Alcohol is a re-

spiratory food, not a poison under all circumstances, as held by some; as a stimulant, it enables the system to use some of its reserve force; when the brain is worried, alcohol may be taken at bedtime with benefit; tobacco in moderation is harmless, except to the young and growing." Chapter VII. treats of the "Effects of Inheritance;" VIII., "The Election of a Pursuit in Life;" IX., "Overwork, and Physiological Bankruptcy;" X., "Mental Strain and Tension," with this as one of its propositions: "Chloral hydrate is a much more objectionable narcotic than either opium or alcohol." In Chapter XI., under the heading "Hygiene," the author treats, in separate sections, of "The House we live in;" "The Air-Supply;" "Ventilation;" "The Water-Supply;" "Sewage;" "Fevers;" "Disinfectants and Antiseptics;" "Vaccination;" "Accidental Poisoning." Chapter XII. is devoted to the treatment of "Emergencies," Chapter XIII. discusses the influence of climate and telluric conditions on health, and concludes the book. The author's style is easy and entertaining, and his book contains a large amount of valuable information.

THE GEOLOGICAL STORY BRIEFLY TOLD. An Introduction to Geology for the General Reader and for Beginners in the Science. By JAMES D. DANA, LL. D., Professor of Geology and Mineralogy in Yale College. 263 pages, 12mo. New York: Ivison, Blakeman, Taylor & Co., 1875. Price, $1.50.

Now that the stories of science are being simplified and told in so many ways, that everybody may hear them, Prof. Dana comes forward and briefly tells *his* favorite story—the geological one. This little book is one of the most interesting and instructive of the briefly-told stories of science published. It fills well the place for which it was intended—an introduction to geology for the general reader and for beginners in the science—and will be specially welcomed as a source of ready and concise information in this branch of study. Scientific terms are defined as they are met with, and the whole narrative is made as popular as possible. After some prefatory suggestions about practical out-door study, the subject of "Rocks, or what the Earth is made of," embracing constituents of rocks, kinds of rocks, and structure of rocks, forms the opening part of the book. Part second treats of the methods by which the different kinds of rocks have been made, and the causes in geology which have formed the geographical features of the earth's surface. Part third deals with historical geology, tracing the succession in the formation of the rocks of the earth, and the progress of life—plants and animals—from the simpler forms of early time up to man. The book is finely illustrated.

ART-LIFE AND THEORIES OF RICHARD WAGNER. Selected from his Writings and translated by EDWARD L. BURLINGAME. New York: Henry Holt & Co., 1875.

THERE is probably no subject which a hasty public opinion would more quickly exclude from the cycle of the sciences than music; and public opinion would be, as usual, both right and wrong. The strictly *scientific* part of music—the systematic collection of the general principles and leading truths relating to it—is of no immediate use to the composer; neither is any particular theory of atoms important to the analytic chemist. Chemistry, however, although at present chiefly an art, claims a place among the sciences, and the modern school of music formulates its theories in scientific guise, and demands a judgment on intellectual and scientific grounds. We must not forget, too, that among the seven sciences of the ancients music was the peer of geometry.

This volume of selections and translations from the writings of Wagner, the founder and the chief exponent of the new school of music, is almost the only means by which Americans can arrive at a conception of the principles which animate it, and of the ideals which it seeks. Wagner is a voluminous writer, and many of his essays are of a quite special nature, so that great judgment was required in selecting such of them as should give the reader a rounded conception of Wagner as a man, as a composer (in reference to his own works), and as a musician, or musical theorist (in reference to the function which music should fulfill, and to the means for attaining its ideal).

With only a casual acquaintance with Wagner's complete works, we may yet un-

hesitatingly say that the selection has been very judiciously made; and, indeed, any one, after reading the volume, will obtain a definite conception of Wagner's personality, which will be felt to be a true conception.

The book opens with a brief introduction, in which the translator explains some of the difficulties which stand in the way of putting Wagner's German into tolerably plain English, and then proceeds to Wagner's autobiography; or so much of it as brings the account down to 1842, since which time his life has been in a great degree a public one.

His youth was idle and stormy, and it was only after hardship and some real misery that he came to thorough work; the determining cause of his action seems to have been an intellectual one, rather than an impulse.

Following the autobiography, come three essays much of the same class: "The Story of the First Performance of an Opera," "A Pilgrimage to Beethoven," and "The End of a German Musician in Paris."

The impressions with which one comes away from the reading of the autobiography are strengthened and amplified by these sketches.

These belong to Wagner as a man, and confirm the rather unpleasant impression which his own life, as written by himself, conveys; he seems to have let his enthusiasm degenerate into waywardness, or rather waywardness was his enthusiasm, and his aspect toward the world in general is disheartening. We are speaking now of Wagner as he was in his earlier years, before 1842, and we recognize the propriety of the selection of the second and third of these essays as exponents of his feeling at that time. Indeed, that must be the sufficient excuse for their selection, as the fictions themselves are of the slightest and most trivial description.

From this point onward we have to deal with quite another phase; not, indeed, with another Wagner, for the unpleasant impression of his personality remains, but with the same Wagner under new impulses or new intellectual motives. To this period belong the two essays on "Der Freischütz," which must be classed among the best specimens of musical literature extant.

They are charming for the keen appreciation of the points involved, and for the skill in which characteristics, good and bad, are brought out and set over against each other. Although these, in time, are of the same epoch as the ones previously noticed, they are an outcome of a decidedly higher phase of feeling.

Then follow essays on the music of the future, the purpose of the opera, musical criticism, and on the production of "Tannhäuser" in Paris. These are fine in all ways, and show how Wagner's musical theories were taking shape, and define, when taken together, what that shape is. We had meant to give this in brief, but find the task no light one, and we must refer the reader to the essays themselves for an explanation. Suffice it to say that Wagner proves, in such a way that all must follow him, that the form of the opera produced by the Italian school is entirely inadequate, not to say absurd. It is absurd poetically, dramatically, and above all musically. He also explains in what way he proposes to remedy these defects, and despite much "fine writing" and vague disquisition an idea may be had of his scheme. Two essays on the plan of the Grand Opera-House at Baireuth show that his ideas may be put into definite brick and mortar, although hard to formulate into words.

The "Legend of the Nibelungen" gives an excellent idea of his skill as an author, and would show to any one not acquainted with his operas that the dramatic situations and the swing and progress of a dramatic climax are likely to be fully understood and adequately treated by him. This volume gives, it seems to us, an adequate idea of Wagner as a man and as a musical theorist. As a man he is not lovable, scarcely admirable. One would call him acute rather than profound. As a theorist, it is impossible to give a suitable judgment in the short limits of a review, which shall not at the same time offend both his friends and his enemies. Any such judgment must be in a large degree personal, and therefore imperfect. Shall we say that *dramatically* and *poetically* he stands alone in *opera*—that *symphonically* he has not yet reached the limits of his master Beethoven—that in dramatic vocal forms R. Franz and Schu

mann are worlds beyond him? He is but the expression of his time—a vague yearning for perfection—an embodied dissatisfaction with his age. He has not, nor will he have ever, reached the dramatic, poetic, and symphonic unity which Händel attained in the "Messiah" a hundred years ago.

His efforts, we think, will be, and have been, of the highest use, and it will be long before music again has such a master of poetry, drama, and song, for a votary; still we sympathize heartily with the accomplished musical critic of the *Tribune*, who speaks of the new school thus:

"The day has gone by when Liszt and Wagner could be decried as mad fanatics. The new music is gaining ground; it is played and sung in every city of the civilized world; we *must* listen to it whether we like it or not; and the wisest of us have determined to like it if possible, or at least to pretend to like it if we can do no more. And yet it is rather saddening to think that the symphony of the future is to be like this Dante symphony (Liszt)—poetic, imaginative, forcible, and thoughtful as it is, but so terribly *hard*. . . .

"It is saddening to be told that there shall never be another Haydn; that the world shall never be gladdened with the bright fancies and graceful sentiment of a new Mozart; that even the idealities of Schumann are fashions of the irrevocable past; that we shall wrestle with melodies as if they were Greek roots, and suffer all the pangs of purgatory before we can work out a tune."

What the new music is, we have learned from Thomas long ago, and we fear that subtile master has made us like it all too well for his and our true progress in art: what its theories and ideals are, we learn authentically for the first time in English speech from this book, and we welcome it, if only that it puts the dogma into a definite, and therefore refutable, form.

Berliner Astronomisches Jahrbuch für 1877. W. Foerster und F. Tietjen. Berlin, 1875.

The *Berlin Jahrbuch*, which corresponds to the English *Nautical Almanac* and to the American *Ephemeris* in part, is published yearly in Berlin, under the charge of the Director of the Berlin Observatory. It differs from the English, and American, and French *Ephemerides*, in that it is a purely *astronomical* year-book, the nautical data being given by a separate publication—the *Nautisches Jahrbuch*—which is at present under the direction of Bremiker, who, as well as Foerster, was one of Encke's pupils, while Encke was the conductor of the *Berlin Jahrbuch*.

The present volume differs little from the preceding ones, but it is fully up to the requirements of the science. It gives: 1. Ephemeris of the Sun and Moon, 100 pages; 2. Geocentric places of the major planets, 57 pages; 3. Heliocentric places of the major planets, 12 pages; 4. Appearances of Jupiter's satellites and Saturn's ring, 8 pages; 5. Mean and apparent places of certain fixed stars, etc., 55 pages; 6. Eclipses, etc., of the year, 24 pages; 7. Auxiliary tables, etc., 6 pages; 8. Ephemeris of the minor planets (asteroids), and list of their approximate geocentric places, 111 pages.

It will be seen that astronomers are well provided for in data from this *Ephemeris*, which, on the whole, is more compendious than any other. It has not, for example, the hourly ephemeris of the Moon which is given in both the English and American *Ephemerides*, but in general it is more convenient than either of these. Its specialty, so to say, is in its ephemerides of the asteroids. Of these, 142 were known at the time of the publication of this volume, and complete ephemerides of 136 are given. It may not be amiss to give a few details with regard to these small planets, as in general little is known of them: 123 of these asteroids have been observed in three different years, and, of these 123, 112 have their orbits so well settled that their places will be sufficiently exact for some time. One of the 123 (*Frigga*) has been observed during three oppositions, and, although its orbit should be well determined, it has not been again found. *Silvia* and *Clymene* were for some years lost, but they have now been successfully sought for and observed. *Maia*, *Dike*, and *Camilla*, of the first 123, have been observed only during one year, and are for the present lost. *Liberatrix* is also lost, and not enough time has elapsed since the discovery of the remaining 13 planets to be certain of their orbits.

It may be said that of the 142 planets known up to February, 1875, at least 92 have their orbits *fully* determined, while only *four* are for the present lost. This is a most admirable showing both for the intrepidity of the computers and the assiduity of the observers. Since February three new planets have been found, two by Dr. Peters, of Clinton, New York, apparently in honor of his safe return from a most successful expedition to observe the transit of Venus, and one by Borelly, of Marseilles. As a *tour de force* in finding asteroids may be mentioned Watson's discovery of No. 139 in Peking, China, during the residence of the American Transit-of-Venus Expedition in that place. It may add to one's conception of the assiduity of astronomers if we remember that in 1800 not a single one of these asteroids was known.

ASTRONOMICAL AND METEOROLOGICAL OBSERVATIONS MADE DURING THE YEAR 1872, AT THE UNITED STATES NAVAL OBSERVATORY. Washington: Government Printing-Office, 1874.

THIS is the eighteenth regular volume of the Observatory publications, which were begun in 1845, and have been continued annually since that time, with the exception of the years 1853 to 1861.

During 1872 the instruments at the Observatory were:

1. The Meridian Transit of 5 inches aperture, and 7 feet 1 inch focal length.

2. The Mural Circle of 4 inches aperture, and 5 feet focal length.

3. The Prime Vertical Transit of 4.8 inches aperture, and 6 feet 6 inches focal length.

4. The Transit Circle of 8.52 inches aperture, and 12 feet 1 inch focal length.

5. The Equatorial of 9.6 inches aperture, and 14 feet 4 inches focal length.

6. Meteorological Instruments.

Of these instruments the first and third were not in use during the year, for lack of observers.

The mural circle was employed during the year in observations of stars whose right ascensions had previously been determined by the transit instrument, and which are included in the Washington "Catalogue" of stars, in the observation of a large number of circumsolar stars from the British Association "Catalogue," and in a few miscellaneous observations, in all about 1,400 observations.

The transit circle was devoted to the observation of the stars of the American *Ephemeris*, to observations of miscellaneous stars, and of the Sun, Moon, planets, and asteroids (of the last, however, only *eight* were observed during the year); 697 stars are found in the "Catalogue," and of these, together with the Sun, Moon, and planets, about 3,700 observations were made. The methods of reduction have remained substantially the same since the instrument was mounted. It is to be noted that the observations made of stars reflected from the surface of Mercury lead to results more and more discrepant each year, so that the latitude deduced from direct observations differs from that from reflex observations by nearly three seconds of an arc in 1872; under these circumstances all the reflection observations of 1871 and 1872 have been rejected.

The equatorial has been used in the observation of the asteroids, of which ten have been observed during the year (a very fine series having been made for three months on *Alceste*), of the companion of Sirius (measures on twelve nights), and of occultations (ten *immersions* and five *emersions*). Besides this a good series of observations was made on the comets of Encke and Tuttle.

The regular meteorological observations (seven observations in twenty-four hours) have been kept up and are given in detail and in means. The indications of the barometer, wet and dry bulb thermometers, maximum and minimum thermometers, solar thermometer and rain-gauge, are recorded at suitable times, and the *direction* and *force* of wind (*force* by estimation only) and cloudiness of sky are also noted. No self-recording meteorological instruments are provided.

The *personnel* of the Observatory consisted, in 1872, of a superintendent (rear-admiral U. S. Navy), of five Professors of Mathematics and three aids (observers), of an instrument-maker, and three watchmen (meteorological observers).

Besides this force several officers of the line of the Navy were detailed to take charge of the chronometers of the Navy, which

are kept at the Observatory, and two Professors of Mathematics were employed on duties other than those of observing.

STORMS, THEIR NATURE, CLASSIFICATION, AND LAWS, with the Means of predicting them by their Embodiments, the Clouds. By WILLIAM BLASIUS, formerly Professor of the Natural Sciences in the Lyceum of Hanover. Philadelphia: Porter & Coates. Pp. 342. Price, $2.50.

THIS volume is an interesting contribution to the literature of an important branch of meteorology. It is a result of many years of observation, and the conclusion of the author is that existing theories of the nature and laws of changes of weather are intrinsically erroneous. Instead of an area of barometric depression being the storm itself, and the *cause* of the movement of the air-current, the storm is the conflict of air-currents of different temperatures, and the barometric depression the *effect* of their movement. Hence atmospheric appearances and phenomena more truly indicate and forecast storm-movements than does the barometer.

The air-currents arise primarily from difference of temperature in the equatorial and polar atmospheres, and in the upper and lower regions of air. In the tendency to restore and maintain the equilibrium thus disturbed originate all the movements known as storms.

These movements will be—1. Vertical, that is, between the lower and upper strata of air. 2. Horizontal, or between the poles and equator.

By these movements, in connection with local circumstances, all modifications of storms are produced. In temperate regions the horizontal movement of storms is most frequent—the vertical most frequent and violent in the tropics.

The formation of a cloud tells us not only that vapor is being condensed in the air, but that warm and cool currents have encountered each other.

In the horizontal movement, the cold and warm currents overlap each other, the vapor-laden warm air from the equator rising over the colder current. A consequence is, the warm air ascends until its waves reach an elevation where condensation takes place along their crests, producing flecks and bars of cloud-caps of the aërial waves. These bars of cloud sometimes span the heavens, rising in the southern horizon, heralding the approach of a northeast storm.

Not until these reach the zenith, says the author, does the barometer announce the approaching change. The storm-area is where these opposing currents encounter each other. The rotary theory of storms he considers defective, and says that the wind blows in all parts of a storm-area in direct lines from the circumference to the centre. So we encounter wind from different directions as the storm passes.

According to the author, observation of the clouds, which are an embodiment of the storm, affords earlier and more trusty data of its approach than the barometer, and the rules for navigators based on the cyclone theory are worse than useless. The theory that storms progress by working their own way, that is, by condensation and rainfall in their front, he says is like a wheelbarrow drawing the man after it.

The work is, in many respects, suggestive, and will be read with interest.

PROGRESS-REPORT UPON GEOGRAPHICAL AND GEOLOGICAL EXPLORATIONS AND SURVEYS, west of the One Hundredth Meridian, in 1872, under the Direction of Brigadier-General A. A. HUMPHREYS, Chief of Engineers, U. S. A., by First-Lieutenant GEORGE M. WHEELER, Corps of Engineers in charge.

THIS thin pamphlet of some 55 pages is really but a fragmentary sample of the long-expected quarto report of the Government surveys of this singularly wild and interesting field. Thus a few specimen full-page plates are given, especially of the weird-like cañons; also a map. The plan of composition is commendably judicious, in that it avoids the journal form; for although it is much easier to sustain a certain sort of interest by means of the narrative method, yet in a scientific work such a form is in great danger of unprofitable extension. Still the story is told in a graphic way, with the results classified, thus giving plan and system, which are indispensable to scientific work. As a sample of the best sort of scientific work, for the reason that it is

complete, and is a part with the above, which is as yet but fragmentary, we would instance Dr. Coues's "Birds of the Northwest," so full and yet so concise; so accurate, and yet so lively. It seems to be for them all a promise that the great Government reports shall stand in striking contrast with that of the famous New York survey—so unmethodical and verbose; so excessive in quantity and so turgid in style.

METEOROLOGICAL OBSERVATIONS IN COLORADO AND MONTANA.

THIS publication is a sort of appendix to the report of Lieutenant Hayden for the year 1874. It consists of tables, based upon the observations of meteorologists stationed at Bozeman, Judith Basin, and Trout Creek, in Montana, and on the summit of Mount Lincoln, at Fairplay, and at Cañon City, in Colorado. The observations at these various places were made three times a day, for the whole of the year 1873, and during the early part of 1874.

LIST OF ELEVATIONS, PRINCIPALLY IN THAT PORTION OF THE UNITED STATES WEST OF THE MISSISSIPPI.

THESE lists, compiled and arranged by Henry Gannett, M. E., form part of Lieutenant Hayden's Report in the Geological Survey of the Territories. Table I. gives the elevation of towns and cities; Table II. those of mountains in the United States; while Table III. states the elevations of various mountains in other countries. The Twin Lakes, in Colorado, have an elevation of 9,357 feet, being situated at the greatest height of any lakes in the United States. Of the States and Territories west of the Mississippi, Colorado has the highest mean elevation, 6,600 feet, and Arkansas the lowest, 350 feet.

ANNUAL ADDRESS BEFORE THE ALUMNI OF THE MEDICAL DEPARTMENT OF THE UNIVERSITY OF PENNSYLVANIA. By CORNELIUS G. COMEGYS, M. D.

THIS address contains many serious and timely reflections upon such topics as state medicine, the physical basis of mind, the effects of cerebral overwork, etc. The history of medical sciences in the present century is briefly but ably sketched. Finally, the author advocates a reform in medical education. The age of teaching by lectures has almost gone by; the demands of science now are demonstrations. The student must be taught to acquire his anatomy, physiology, physics, chemistry, pathology, materia medica, and practical medicine, with his own hand and eye. The classes of clinical medicine, above all, should consist of small groups, in order to secure the closest personal scrutiny of the phenomena of disease, and of the effects of modes of treatment.

BULLETIN OF THE UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES. Numbers 2 and 3, Second Series. — No. 2 contains able papers by Ridgway, Coues, Gill, and Ingersoll. These papers are severally contributions to zoölogical science, and in this intense technical shape are meant to commend themselves simply to hard workers in the field. No. 3 is mainly topographical, and contains several plates and maps.

THE BROOKLYN JOURNAL OF EDUCATION. —The external appearance and *matériel* of this publication are very attractive, and by themselves alone are calculated to win for it public favor. The editorial management appears to be no less excellent; and with both of these conditions combined there is no reason why the *Brooklyn Journal of Education* should not meet with distinguished success. Among the articles in the first number is one on the Packer Institute, being the first of a series on the educational institutions of Brooklyn. Dr. Jerome Walker writes concerning the *physique* of public-school teachers. "The Philosophy and Methods of Primary Instruction" is treated by James Cruikshank. The periodical has special science and art departments. $2.50 per annum.

PUBLICATIONS RECEIVED.

Six Notes de Chimie Moléculaire. Par M. Gustave Hinrichs. Paris: 1873–'75.

Moments and Reactions of Continuous Girders. By Mansfield Merriman, C. E. Pp. 23.

Principia, or Basis of Social Science (Wright). Lippincott & Co.

Bad Health of American Women. By James E. Reeves, M. D. Wheeling, Va. Pp. 43. Price, 50 cents.

Animal Volition a Creator. By C. G. Forshey. (New Orleans Academy of Sciences.)

Papers read before the Pi Eta Scientific Society of Troy Polytechnic Institute. Pp. 74.

Oldbury. By Annie Keary. Philadelphia: Porter & Coates. Pp. 420. Price, $1.25.

The Complete Arithmetic. *Also*, First Book in Arithmetic (Fish). Ivison, Blakeman, Taylor & Co.

Determination of Minerals by Blow-pipe (Danby). London: Field & Tuer.

St. Louis Public Schools.

Bulletin of the Bussey Institution.

Morgan Expedition, 1870–'71.

Archæological Researches in Kentucky and Indiana (Putnam).

Hygiene of the United States Army.

MISCELLANY.

Fish-Culture.—The results so far attained in this country in the artificial culture of fish are eminently satisfactory, and the efforts made by the various fisheries commissions to increase the supply of food for the people are worthy of all commendation. Naturally, there existe a lively public curiosity to know the processes of fish-culture, and information with regard to its history, its principles, and its methods, is heartily welcomed. In response to this general demand, Mr. Robert B. Roosevelt, Fish Commissioner of the State of New York, has given a public lecture on pisciculture, in which he very fully considers the subject in all its aspects. The lecture is very long, and we must be content with indicating only a few of its points. There are, he said, two divisions of fish in our country which are subjects of fish-culture, viz., the *Salmonidæ*, or salmon-tribe, and the *Alosidæ*, or shad-tribe. Under the former head are included the salmon, the trout, the salmon-trout (or lake-trout), the white-fish, and the California salmon. The *Alosidæ* are represented in pisciculture only by the shad, as yet.

The first point in fish-culture is to obtain the spawning-fish in proper condition. In the *Salmonidæ*, the eggs, when in a perfectly ripe condition, lie free in the abdomen, and may be extruded by gentle pressure. They are caught as they fall in a basin, and are vitalized by coming in contact with the milt from the males. Formerly, the practice obtained of having this basin full of water, it being supposed that this arrangement more nearly reproduced the natural conditions; but subsequent discoveries led to a change of this method. The eggs are fertilized by the spermatozoa of the milt entering through the micropyle, and taking up board and lodging within. It was ascertained, however, in practice, that these spermatozoa are not fond of water, and, although very active when first emitted, soon drowned. They retain their vitality much longer when dropped among the eggs in a comparatively dry state, and this is the method universally pursued at present.

As soon as the operation is completed, the eggs are placed in hatching-troughs. These are made of various materials, but are simply long, narrow boxes, say twelve feet long by eighteen inches wide, and subdivided into compartments, to keep the eggs from crowding on one another. Cold spring-water, which has been carefully filtered by passing through several flannel screens, comes in at the head of these troughs, passes over the eggs, in one compartment after another, and escapes at the lower end. By this means the greatest dangers to the life of the embryo are avoided. Sediment and confervæ cannot pass the screens, insects are kept out altogether, and ducks and eels are disappointed of their prey. The eggs require about two months to hatch, with the water at the temperature of 45°. They demand constant care and attention, for, if one egg dies or becomes diseased, it contaminates its neighbors. The advance of the process is, however, soon visible in the egg, either to the human eye or under the microscope. At last the pisciculturist will have evidence of his labors being successful. Some morning, on going to his troughs, he

will notice broken egg-shells in the water, and, on closer inspection, will observe wriggling nondescripts on the bottom, neither like fish nor eggs, but compounded of both. When they once begin to appear, they come in thousands, in millions, in myriads. The young need more water, at this time, but require less care; yet still they must be watched. The young fish may soon be turned loose into the stream.

If he is a salmon, after a few months' preparation to strengthen his sinews and test his power, he goes down to the sea, there to dwell, and feed, and grow, gaining wonderfully in size, drawing his sustenance from the exhaustless storehouse of the world, and coming back to man, in a few months, a magnificent embodiment of strength and beauty, bringing to the lord of the universe five or ten pounds of as delicious food as ever delighted a gourmand's palate, or satisfied a hungry man's stomach. If he is only a trout, a younger brother of the glorious family of the *Salmonidæ*, he will lurk about the bottom of some pond, or graze some pebbly mountain-brook, and struggle up to a half-pound or more before twelve months shall have rolled over his head.

Heat evolved by Friction of Ice.—Mr. A. Tylor, in a paper recently read before the Geographical Society of London—a synopsis of which was published in *Nature*—shows that heat evolved by friction of ice upon ice is an important element in glacial movement. By a simple apparatus he reduced ice to water in a temperature of 32°, at the rate of one and a quarter pound an hour, by friction only of ice upon ice, the pressure applied being but two pound to the square inch. By simple evaporation, the ice in the same temperature lost one-quarter of a pound in the same time.

In a temperature of 54° the production of water under friction was three and a quarter times greater than by simple melting when there was no friction.

The actual heat evolved by friction of ice upon ice is nearly the same as from oak upon oak, when well lubricated.

In the motion of glaciers great quantities of water are continually discharged, lubricating the bottom. Surface-melting of the ice Mr. Tylor considers insufficient to produce it. The bottom of a glacier, with its rasping under-surface of rock and sand, slides, to some extent, upon the bottom, and much heat is evolved in this way, but in innumerable fractures of the sides of the glaciers, of the surface-ice flowing on and over bottom-ice, there are friction and attrition, ice moving against ice, which melts it, and the water percolates through the fractures to the bottom.

In great glaciers the pressure is enormous. With ice a mile thick it is half a ton to the square inch, and the quantity of water produced increased accordingly.

Economic Value of the Sunflower.—The common sunflower is a native of tropical America, and there it sometimes attains the extraordinary height, for an annual plant, of twenty feet. It thrives in nearly every region of the inhabitable globe. In the south of Europe and in the northwest provinces of India it is cultivated to a considerable extent. In the latter country, sunflower-plantations are said to have a very beneficial effect in promoting the healthfulness of regions infested by malarious fevers. The seeds are valued as food for cattle and poultry, and an oil may be expressed from them which is scarcely inferior to olive-oil. One acre of good land will produce about fifty bushels of seed, each bushel yielding a gallon of oil. The seeds are also used like almonds for making soothing emulsions, and, in some parts of Europe, a food for infants is prepared from them. In tropical America the Indians make bread of them. The leaves are used as fodder for cattle, and the stalks, when burned, yield large quantities of potash.

The plant called Jerusalem artichoke is doubly misnamed; it has as little to do with the Holy City as the soup made from its tuberous roots has to do with the Promised Land, and yet the former is called Jerusalem (from the Italian *girasole*—sunflower), and the soup is called "Palestine," because it contains "Jerusalem." It got the name of "artichoke" from a resemblance in taste between its tuber and the flower-receptacles of the true artichoke, but it differs totally from that plant in botanical characters. The Jerusalem artichoke is a species of the sunflower, and, like all sunflowers, a native of

tropical America. It has a straight stem, eight or ten feet in height, and produces yellow flowers like those of the sunflower, but smaller. The thick, fleshy, perennial root produces a large number of tubers, in appearance not unlike potatoes. These are not as nourishing as potatoes, but, when properly prepared, are very palatable food, and make a very good soup. It is usually propagated by small tubers or by cuttings, like the potato.

Toughened Glass. — A process for increasing the cohesive power of glass has been invented by a French engineer, François de la Bastie. This process consists in heating the glass to a certain temperature and plunging it while hot into a heated oleaginous compound. The time occupied in the actual process of tempering is merely nominal, for directly on being heated to the requisite degree, the articles are plunged into the bath and instantly withdrawn. The toughened glass cannot be cut by the diamond, and hence when it is used for windows it must be cut to the proper size before it is tempered. Articles of this toughened glass, such as watch-crystals, plates, dishes, and sheet-glass, were recently exhibited in London, and experiments made to show wherein this material differs from common glass. Water was boiled in a saucer over a fire, and the saucer quickly removed to a comparatively cold place; it was unaffected by the sudden change of temperature. One corner of a piece of glass was held by the hand in a gas-flame until the corner became exceedingly hot, but the heat was not communicated to the other portion of the glass, nor was it cracked from unequal expansion.

The following experiment was then made to show how this toughened glass compared with common glass in power of resistance to fracture by the impact of a falling weight. The two pieces of glass to be tested were each about six inches square, and placed in frames, the weight being dropped upon the centre. With the ordinary glass, a two-ounce brass weight, falling on it from a height of twelve and eighteen inches respectively, did no damage, but at twenty-four inches the glass was broken into fragments. With a thinner piece of the toughened glass no impression was made by the same weight falling from heights ranging from two to ten feet, the weight simply rebounding from the glass. An eight-ounce iron weight, tried at two to four feet respectively, gave similar results. The height being increased to six feet, the glass broke.

Some of the public prints have ascribed to Bastie's tempered glass properties which the inventor himself has never claimed for it. Thus it has been qualified as "malleable" and "unbreakable." But Mr. Thomas Gaffield, of Boston, a perfectly competent judge, who has examined specimens of this tempered glass, thinks that the true value of this invention is by no means determined as yet. He perceives in it sundry qualities which detract from its usefulness. First, as we have stated, it cannot be cut by the diamond. Then, on being subjected to the sand-blast, it flies into small fragments. Many of the specimens seen by Mr. Gaffield were not transparent, but only translucent. In ordinary window-glass, if a large pane be broken, the fragments may be cut into smaller panes, but with the De la Bastie glass such economy is out of the question. From the fact that this improved glass, though before the public for a whole year, has not yet found a place in commerce, Mr. Gaffield is inclined to suspect that the invention is for some reason impracticable.

Can Birds converse? — Dr. Charles C. Abbott cites the following occurrence to show that birds possess some mode of conveying ideas to one another. In the spring of 1872 a pair of cat-birds were noticed carrying materials for a nest to a patch of blackberry-briers hard by. To test their ingenuity, Dr. Abbott took a long, narrow strip of muslin, too long for one bird conveniently to carry, and placed it on the ground in such a position as to be seen by the birds when searching for material. In a few moments, one of the cat-birds spied the strip and endeavored to carry it off; but its length and weight, however he took hold of it—and he tried many times—impeded his flight, and, after long worrying over it, the bird flew off for assistance. In a few moments he returned with his mate, and then, standing near the strip, they ap-

peared to *hold a consultation*. The chirping, twittering, murmuring, and occasional ejaculations, were all unmistakable. In a few moments these all ceased, and the work commenced. Each took hold of the muslin strip, at about the same distance in each case from the ends, and, taking flight simultaneously, bore it away. Soon there was much jabbering at the nest: the birds could not agree how to use the strip, and it was finally abandoned; but so, too, was the nest, and the birds left the neighborhood.

Parasite in a Child's Mouth.—At a meeting of scientific men lately held in New Brunswick, New Jersey, Prof. Lockwood exhibited a thread-worm which, he said, was sent him by a student of Rutgers College, two years ago, who found it in an apple which he was eating. It looked so like an animal parasite that the professor was puzzled to fix its character. He stated that Prof. Leidy had recently described before the Academy of Natural Sciences, at Philadelphia, the same worm, also taken from an apple; who also said that this worm was a parasite of the larva of the codling moth, whose grub, or larva, as is well known, infests the young apple, feeding inside of it, and thus causing it to fall from the tree to the ground, when the larva leaves the fruit and enters the ground, in which to pass its pupa state. Thus the worm, whose name is *Mermis acuminata*, was really an animal parasite, sustaining its own life apparently by a vegetable diet, after the death of the larva codling, either by absorption, or its own consumption of it. Dr. Leidy called the attention of the Academy to the fact that twenty-five years ago he described before them the same entozoön taken from the mouth of a child. At that time he was ignorant of the origin of the parasite. It now seems fair to infer that the child had been eating an infested apple, and that the worm had a second time changed its *nidus* for that of the child's mouth.

Summer Temperature of Scotland.—Mr. McNab, Director of the Edinburgh Botanic Garden, last year published some facts going to show that the mean summer temperature of Scotland has been growing colder during the last two or three generations. According to Mr. McNab, sundry plants which thrived in Scotland fifty or seventy-five years ago can now scarcely be grown there. Mr. William Tillery communicates to the *Gardener's Chronicle* several other facts confirmatory of McNab's conclusions. Forty years ago, nearly all the gardens of note in South Ayrshire used to exhibit at the horticultural shows peaches and nectarines grown on walls in the open air. Some good white and black figs were likewise ripened on the open walls in favorable summers; but this is of very rare occurrence now. At the present time, gardeners in the most favored districts of Scotland and in Northern and Midland England are lamenting the unproductive state of their peach and nectarine trees in the open air. A weather-register, kept for the last thirty-eight years, shows that of late years the winters have been more open, the frosts in the spring months later and more severe, and the rainfall more irregular, than formerly.

International Weather Reports.—It has been proposed to establish an exchange of telegraphic weather reports between the Signal-Office at Washington and the meteorological bureaus of the various countries of Europe, and it is claimed that such exchange would be likely to afford valuable data for forecasting the weather on both sides of the Atlantic. Mr. W. Clement Ley, who has worked for a considerable time at the comparison of United States with European weather-charts, holds that such exchange would be undesirable for Europe, on the following grounds: 1. Only a small proportion of the storms experienced on the American side of the Atlantic can subsequently be distinctly traced in Europe at all. 2. Of those thus traceable, the majority are felt severely only in the extreme north of Europe, and are not productive of serious results on the coasts of Britain, France, or Denmark. 3. The velocity of their progress varies indefinitely, and could not be deduced from the velocity of the currents experienced in them, even if the latter were not variable also. 4. Many of the most destructive European storms occur when pressures over the Eastern United States coast

are tolerably high and steady. In such instances attention to the telegrams would in all probability mislead. In conclusion, Mr. Ley says: "The connection between the weather periods on the two sides of the Atlantic is one of the problems which the progress of research is steadily, though slowly, attacking. But such research can be carried on without embarking on a system of weather telegraphy, which is unlikely to be practically beneficial, and the failure of which might rather tend to bring this branch of the science into disrepute."

Where do the Grasshoppers belong?—Prof. Riley's Seventh Report contains most valuable facts relative to the natural history and geographical distribution of the grasshopper (*Caloptenus spretus*) which has caused so much human suffering by its destruction of crops in the Western part of this country. It appears, from the Report, that the late Mr. Walsh, State Entomologist of Illinois, had previously predicted that the insect would not reach the Mississippi River, and, so far as known, subsequent facts bear out the statement, although the reasons stated for the limitation of the species to its present territory are not entirely satisfactory. Prof. Riley exclaims (pp. 165, 166): "Well is it for the people of Missouri, well is it for the people of the Mississippi Valley generally, that this insect cannot go on multiplying indefinitely in their fertile fields. Else, did it go on multiplying and thriving as the Colorado potato-beetle has done, this whole valley would soon become a desert waste. A wise Providence has decreed thus far it shall go and no farther." To the "wisdom" of this "Providence" the poor people of Kansas, Nebraska, etc., may well object, and very naturally withhold their approval from Prof. Riley's biblical rhetoric. It would rather seem, also, from Prof. Riley's map of the portion of Missouri overrun already by the grasshopper, that all the citizens of that State cannot agree that it is "well with them;" but some must be even content to share in the suffering of the farmers of Kansas and Nebraska. As to the "valley of the Mississippi," an inquiry as to the probability of cotton-fields and sugar-plantations affording the proper kind of food for the grasshopper will be in order before Southerners may consider themselves as the chosen people of Prof. Riley's geographically discriminating "Providence." The fact that the cotton-worm (*Aletia argillacea*) migrates as far north as Canada, though not breeding beyond the limits of the growth of the cotton-plant, would show the possibility of the grasshopper exceeding its present range in favorable seasons, and in localities where the food and soil are congenial. —A. R. Grote.

Social Feeling in Dogs.—A correspondent furnishes the following statement, for the truth of which he vouches: "A gentleman residing a few miles from Brooklyn, on Long Island, had recently two dogs which for several years had shown marked attachment for each other. One day he noticed that one of the dogs was ill, and the following morning found him dead in the barn, where he was accustomed to sleep. The other dog, which slept in the house, left in the morning when the gentleman went out, lively and playful as usual, and on the barn-door being opened bounded in, and saw his companion dead on the floor. Having smelt of him, he looked at him intently for more than a minute, and started for the house, with drooped ears and tail, evidently in distress—certainly he knew that a great change had taken place in his companion. At breakfast the dog refused food, nor did he eat thereafter; his usual cheerfulness gave place to melancholy, and in a few days he died."

A Curious Fog.—Dr. R. Angus Smith describes, in a recent pamphlet, a peculiar sort of fog observed by him in Iceland. On a bright July afternoon Dr. Smith happened to be in Reikjavik, and saw a cloud coming down the street from the southward. Finding that it moved very slowly along the ground, he concluded that it was smoke from a chimney, but smoke mixed with larger particles than are usually seen. When the fog reached the spot where the observer stood, it was found to be devoid of smell, but its influence was decidedly frigorific. Perceiving that it was a fog, Dr. Smith ascended a rising ground, and saw the fog coming from a small lake be-

hind the town, and rolling into the streets very slowly. A similar fog rose from the sea, and rolled, also, into the town. Hence it appeared that the wind had nothing to do with the matter, but that both fogs rolled because they were too heavy to remain suspended. The peculiarity of the fog was in the size of its particles, larger than any the author had ever before seen, and which he estimated at from $\frac{1}{40}$ to $\frac{1}{300}$ of an inch in diameter; another peculiarity was its lumbering mode of rolling, in which it resembled dust. The author found that the particles were perfectly spherical, and not hollow, but concrete throughout.

Food-Rations of the French People.—A very curious calculation has been made by M. Hervé Mangon to determine the average ration *per kilogramme of live weight* consumed by the rural population of France. He estimates the "live weight" of the French people in 1861 at 1,771,142,951 kilogrammes (say 3,896,514,492 lb.). But these figures, though they represent fairly enough the total weight of the population, cannot serve as a basis for estimating the amount of food required. Children consume more food, in proportion to their weight, than adults. Hence, the author was obliged to express the weight of children, not as it actually was, but in terms corresponding to their consumption of food. In this way he finds the total weight of the French population to be, from the point of view of nitrogen-consumption, 2,112,978,201 kilogrammes (4,648,352,042 lb.), and from the point of view of carbon-consumption 2,095,886,031 kilogrammes (4,610,949,268 lb.). The food annually consumed in France contains carbon 4,434,716,270 kilogrammes (9,756,375,794 lb.); nitrogen 215,724,211 kilogrammes (474,593,264 lb.). If, now, we divide the sum of the carbon and nitrogen by 365 days and then divide the quotient by the total weight of the population, we find the mean daily rations per kilogramme (2¼ lb.) of live weight to be, carbon, 5.1797 grammes (77.7533 grains); nitrogen, 0.280 gramme, (4.3212 grains). This is the daily ration per kilogramme for the whole population.

In Paris the daily ration *per "live kilogramme"* contains 5.675 grammes of carbon, and 0.332 gramme of nitrogen. Supposing, now, that the daily consumption per kilogramme is the same in Paris, Lyons, Marseilles, and the six other cities whose population exceeds 100,000 souls, the mean daily ration per kilogramme of weight for the country districts is found to contain, of carbon 5.808 grammes, and of nitrogen 0.275 gramme. This ration M. Mangon considers to be sufficient to fit the body for a moderate amount of labor; but it would be good economy, he holds, for employers to give their servants and workmen more abundant food. The dullness and slowness of country people he regards as the natural result of insufficient food.

Relations of Meteorology to Life.—At a recent meeting of the British Meteorological Society a communication from the Council was read, entitled "Suggestions of the Observation of Periodic Natural Phenomena," the object being to call attention to those phenomena manifested by organized beings of the vegetable and animal kingdoms dependent on the progression of the seasons, such as the budding, leafing, flowering, fruiting, and the shedding of leaves of trees, shrubs, and herbaceous plants; the earliest and latest appearance of insects; the times at which birds pair and build, and of the arrival and departure of birds of passage; the periods of hibernation of reptiles and small animals, as frogs, dormice, etc. All these phenomena being closely connected with the annual progression of the meteorological elements, are calculated to afford information of the progression of the seasons, of a much more interesting character than that derived from the indication of instruments. Plants are very susceptible of atmospheric influences, and a close correlation exists between the development of plant and animal life as the sun advances in his yearly course, each season being marked by its characteristic phenomena.

The Marriage of Cousins.—The influence of marriage of first cousins on the mental constitution of the offspring is almost universally pronounced to be deleterious. This subject has been treated by Mr. George H. Darwin in a paper read at a meeting of the London Statistical Society. Mr. Darwin's

method of obtaining facts upon which to base an induction was by diligent study of Burke's "Peerage," and by sending out circulars of inquiry to members of the upper and middle classes, and to directors of asylums for the insane. The result showed that insanity, idiocy, and deaf-muteness, are in the United Kingdom about evenly divided, *pro rata*, among the progeny of consanguineous and of unconsanguineous marriages; that is to say, Mr. Darwin's investigations have failed to show any evil accruing from the marriages of first cousins. Mr. Darwin acknowledges that the opinion of prominent medical men is against such intermarriages, and that a general consent of physicians possesses far greater weight than his own purely negative results. "My paper," he adds, "is far from giving any thing like a satisfactory solution of the question as to the effects of consanguineous marriages, but it does, I think, show that the assertion that this question has already been set at rest cannot be substantiated. The subject still demands attention, and I hope that my endeavor may lead more competent investigators to take it up from some other side."

A New Ornamental Evergreen. — The myrtle-tree of Oregon attains a height of from twenty to fifty feet, and a diameter of from six to twenty inches. Dr. F. S. Matteson, who describes this beautiful tree, in the *Boston Journal of Chemistry*, says that it is an evergreen of very full foliage, with leaves three inches long and half as broad, of a deep shining green color; they are delightfully fragrant. The wood is hard, heavy, fine-grained, and takes a high polish; when varnished it is of a dark, variegated color, and is scarcely inferior to rosewood. The tree is very tenacious of life, sprouts freely from the stump after the tree is felled, and is a vigorous, upright grower. It blossoms in early spring, and the best honey in the world is gathered by bees which work in the myrtle-groves. Settlers are cutting down these groves for lumber and fuel, and the timber is burned in heaps to clear the land. Many trees are left standing for the sake of ornament. The nuts afford good food for swine. This tree must certainly become a leading evergreen for ornamentation, as it is unsurpassed by any known tree for all the qualities which make an evergreen desirable. Dr. Matteson thinks it probable that a highly-fragrant oil, useful as a perfume, and perhaps for medical purposes, may be distilled from the leaves.

American Origin of the Chinese. — The colonization of the American Continent from the "Old World," so called, is one of the commonplaces of historical speculation; the colonization of a large portion of the "Old World" from America is a theory of more recent origin, and yet perhaps as plausible as the one which it is intended to supplant. At a meeting of the California Academy of Sciences, Mr. Charles Wolcott Brooks read a paper on the "Origin of the Chinese Race," in which he very learnedly set forth the evidence of their American origin. The author's thesis is supported by a great multitude of facts, but the space at our command will admit only of the barest outline of his argument. According to Chinese annals, Tai Ko Fokee, the great stranger king, ruled the kingdom of China. In pictures he is represented with two small horns, like those associated with the representations of Moses. He and his successor are said to have introduced into China "picture-writing," like that in use in Central America at the time of the Spanish conquest. He taught the motions of the heavenly bodies, and divided time into years and months; he also introduced many other useful arts and sciences.

Now, there has been found at Copan, in Central America, a figure strikingly like the Chinese symbol of Fokee, with his two horns, and in like manner there is a close resemblance between the Central-American and the Chinese figures representing earth and heaven. Either one people learned from the other, or both acquired these forms from a common source. Many physico-geographical facts favor the hypothesis that they were derived in very remote ages from America, and that from China they passed to Egypt. Chinese records say that the progenitors of the Chinese race came from across the sea. But the Pacific is a wide ocean to cross, and favoring winds must have been taken advantage of to carry the emigrants from shore to shore. Mr. Brooks then ex-

plained the action of the southeastern and northeastern trade-winds, and argued that, if large junks started from the coast of Peru and kept before the wind, they would in all probability strike the southern coast of China. America is geologically the oldest continent; if so, why not the first peopled? When in the development of America her progress was sufficient to facilitate emigration, why may she not have given a population to Asia? If the primitive races of this continent have died out and their memorials crumbled away, this is a strong argument in favor of the antiquity of the human race here: in more recent Asia traces still remain of original races.

Respiration and Versification. — The natural rate of respiration is from sixteen to twenty-four breaths per minute, the average being twenty. To this fact Dr. Oliver Wendell Holmes attributes the favor in which the octosyllabic verse is held: that verse, more exactly than any other, follows the natural rhythm of respiration. Experiments with the poetry of Scott, Longfellow, and Tennyson, show that an average of twenty lines will be read in a minute, so that one respiration will suffice for each line. It is, in fact, so easy of articulation, that it is apt to run into a sing-song. The twelve-syllable line of Drayton's "Polyolbion" is pronounced almost intolerable, on account of its "intensely unphysiological construction." Dr. Holmes's conclusion is, that nothing in poetry or in vocal music is popular that is not calculated with strict reference to the respiratory functions.

Diseases of Artisans.—The diseases incident to the following of various trades are considered in detail by a German physician, Dr. Hirt, in his work "Diseases of Artisans." The effects produced by the inhalation of certain gases are discussed by the author in the second division of his work. With regard to carbonic acid he confirms previous observations of the acute affections produced by it, but he does not find the slightest evidence in favor of chronic intoxication by the constant inhalation of small quantities of the gas. In the processes of beer-brewing, wine-making, distilling and yeast-making, considerable quantities of carbonic acid are given off, but, wherever the ventilation is good, no injurious effects are produced. He appears to have no doubt of the occurrence of chronic poisoning by the action of sulphuretted hydrogen. The symptoms are general weakness, depression and usually total loss of appetite, combined with a feeling of weight on the stomach: the tongue is furred. Bisulphide of carbon, obtained by passing sulphur-fumes over burning coal, and subsequent distillation, is now much used as a solvent of India-rubber. It produces chronic poisoning. The symptoms are, at first, evening headache, and pains in the limbs; sometimes intellectual excitement; often cramps, difficulty of breathing, and increased frequency of the heart's action. After some weeks or months follows a period of depression, heaviness, insensibility of some parts of the skin, diminution of sight, and in some cases of hearing. The bad-smelling gases and effluvia given off from putrefying animal substances are said to be innocuous. The trades exposed to such emanations are tanners, soap-boilers, candle-makers, etc. Workmen get accustomed to the fumes of turpentine, and then such fumes appear to have no injurious effects.

NOTES.

ERRATA.—In the article entitled "Absorption of Water by growing Grain," on page 380 of present volume, for "1,796 grammes," *read* "1.796 gramme," and for "two-fifths of an acre," *read* "2.5 acres."

WE note the formation of three new associations for the study of natural science, viz.: the Lyceum of Natural Sciences, at San Diego, California; the Natural History Club, of Vineland, New Jersey; and the Nebraska Association for the Advancement of Science, at North Platte, Nebraska.

ADMIRAL SHERARD OSBORN, of the British Navy, who died on May 6th, in the fifty-fourth year of his age, first gained distinction in the expedition which sailed to the polar regions in search of Franklin in 1849. Again, in 1852, he commanded a vessel which took part in a second expedition on the same errand.

A VIRULENT disease of the lungs, bearing some resemblance to the *epizoötic* which appeared in the United States about two years ago, broke out among the horses at Hull, England, last March. The malady is described as very infectious, and as having carried off a large number of animals.

Died suddenly, on June 11th, at the age of forty-nine years, Joseph Winlock, Director of the Cambridge Observatory, and Phillips Professor of Astronomy in Harvard College. The deceased was a native of Kentucky, and from 1845 till 1852 was Professor of Mathematics in Shelby College, in that State. He then removed to Cambridge, where he was employed in making computations for the *Nautical Almanac*. Later he was appointed Professor of Mathematics for the United States Navy, and served as assistant in the Washington Observatory, superintendent of the *Nautical Almanac*, and Director of the Mathematical Department of the Annapolis Academy. From 1865 till his death he was connected with the Cambridge Observatory and Harvard College.

The fifteenth annual meeting of the National Educational Association will be held in Minneapolis, Minnesota, on Tuesday, Wednesday, and Thursday, the 3d, 4th, and 5th days of August. The officers of the Association are: President, William T. Harris, St. Louis; Secretary, William R. Abbott, Bellevue, Virginia; Treasurer, A. P. Marble, Worcester, Massachusetts.

Committee "F" of the United States Board for testing iron, steel, etc., request information as to the behavior of rails and machinery exposed to the extremes of temperature observed in northern latitudes, when subject to wear or to breakage. Specimens, photographs, results of analysis, statistics of railroads, statements from rolling-mills, published or unpublished essays—in short, information of any kind upon the subject may be sent in to the committee, R. H. Thurston, chairman, Stevens Institute, Hoboken, New Jersey.

An elaborate work by A. R. Wallace, on the "Geographical Distribution of Animals," is announced as soon to be published by Macmillan. It will be in two volumes, illustrated with many maps and woodcuts.

Mary Putnam Jacobi, M. D., of New York, has recently received from Paris, says the *Tribune*, the bronze medal awarded three years ago by the Academy of Medicine for her graduating thesis. In the competition Mrs. Jacobi attained the rank of from fifth to eighth in a class of 300, all men except herself. And yet Paris medical journals are complaining that "the admission of women students to the Academy has lowered its standards!"

It is stated in an Albany journal that Seth Green has succeeded in hatching a large number of sturgeon-eggs. It is intended to stock the Hudson River with sturgeon, a fish which at one time was very abundant in that stream, but which has for years been declining in numbers.

The Swedish Arctic Expedition of the present year was to have sailed in June for Nova Zembla. It will first study the botany, zoölogy, and ethnology, of the south of the island, and then advance along the west coast to the northernmost point. Thence it will advance to the northeast to explore this unknown part of the Polar Sea. It then goes south to the mouth of the Obi and the Yenisei. Here the explorers will quit the ship and go up the river in boats, returning home afterward by land. Prof. Nordenskiöld commands the expedition. A wealthy merchant, Oskar Dickson, bears all the expenses.

In excavating near Rideau Hall, Ottawa, the residence of the Governor-General of Canada, the workmen made an interesting geological discovery. They came upon a stratum of fossil-rock several feet thick, containing beautiful petrified winged insects. Some of these are like butterflies, with the delicate fibre of the wings in a perfect state of preservation.

During the last fifty years the water-level of the rivers Elbe and Oder has fallen 17 inches, that of the Rhine 24, of the Vistula 26, and that of the Danube as much as 55 inches at Orsova. And there is a similar decrease in the water-supply from springs in Germany. The cause of this decline is attributable to the present reckless cutting down of forests, as also to the artificial drainage now so generally adopted by farmers.

Dr. Paul Bert, distinguished for his researches on the physiological effects of atmospheric pressures, has been chosen President of the French Aëronautical Society. Gaston Tissandier is one of the vice-presidents.

The work of the Geological Survey of California having been suspended by the State Legislature, a vast collection of botanical observations remained in manuscript, which the State refused to have printed. Prof. Gilman has succeeded in raising a subscription of $5,000, for the purpose of publishing this valuable material. The funds were contributed by nine public-spirited citizens of San Francisco.

Spectacle-frames with fine wire gauze in place of glass are found to answer perfectly for the protection of the eyes from dust in various trades and occupations, such as stone-cutting, thrashing, etc. Such spectacles permit the necessary access of air to the eye, and produce no inconvenience to the wearer.

The best authorities consulted by the British insurance companies, as to the advisability of putting an extra premium on the policies held by the members of the

Arctic Expedition, were of opinion that the risks were not so great as on the west coast of Africa, and hence no extra premium was exacted.

THE extension of railways in India is gradually undermining the institution of caste. In a lecture on this subject, Mr. Framjee R. Vicajee, a native of Bombay, said that in England the only caste which the railway class-system protects from contamination is that which is based on wealth; but in India, which is a poor country, really high-caste people travel third class to save their money, while in England they travel first-class to save or assert their caste.

THE mean height of Europe is estimated by Dr. G. Leitpoldt at 974 feet. Switzerland shows the maximum mean height, 4,624 feet, and the Netherlands the minimum, 31 feet. Intermediate are Spain and Portugal, 2,298 feet; Austria, 1,698; Italy, 1,696; France, 1,292; British Islands, 714; Germany, 701; Russia, 548; Denmark, 115.

ACCORDING to Dr. Otto Krause, tobacco-smoke always contains a considerable quantity of carbonic oxide, and the after-effects of smoking are principally caused by this poisonous gas. Dr. Krause holds that the after-effects are all the more energetic, the more inexperienced the smoker is, and he thus explains the unpleasant results of the first attempts at smoking, which are generally ascribed to nicotine alone.

THE practice of vaccination is making fair progress in India. One obstacle is the religious scruples of the people, but the medical officers state that these may now be overcome by the payment of one *auna* (three cents) per child.

THE water of a much-esteemed mineral spring in England was, on chemical analysis, found to contain in very large proportion every known form of impurity, viz., oxidizable organic matter, ammonia, chlorides, nitrates, nitrites, living organisms, and decaying vegetable matter.

Two instances are mentioned in the *Lancet* of undoubted transmission of disease from human beings to domestic animals. In one case whooping-cough was communicated to a cat from children. In the other case dogs took small-pox from persons suffering from that disease.

IT is announced by the Norwegian papers that the Government have voted about $25,000 toward a scheme for the prosecution of deep-sea investigations between Iceland, Spitzbergen, the Faroe Islands, and Jan Mayen Island. Operations will be conducted on the model of the Challenger's researches.

THE following instance of canine sagacity and fidelity is reported in *Land and Water:* A man named Colville left his home near Dunfermline, accompanied by his dog. He did not return that day, but the next afternoon the dog came home, and behaved in a very eccentric manner, apparently endeavoring to attract attention. Seeing that the animal continually rushed off in the same direction, and that he evidently wanted some one to go with him, Colville's friends resolved to follow him. The dog led them to a disused coal-shaft, and there stopped. Grappling irons were procured, and the dead body of Colville was soon brought to the surface.

IN the *Annals and Magazine of Natural History* for January, 1875, Captain F. W. Hutton gives a technical description of two new species of crustacea recently discovered in New Zealand.

THREE years ago an American tourist, John Blackford, lost his life in an attempt to ascend Mont Blanc without a guide. His body was recently found in a large ice-block after several days of thaw. Features and clothes were in a perfect state of preservation.

THE Fish Commissioners of Pennsylvania and New Jersey, says *Forest and Stream*, are preparing to engage more actively than ever in shad-culture on the Delaware. Hatching-boxes have been located at three different stations, viz., Point Pleasant, Trenton, and Howell's Fishery.

SAYS the *Lancet:* "Another case of inflammation of the feet, caused by the wearing of socks with orange-red stripes, has occurred. The victim this time is Mr. Hart Dyke, the Conservative Whip. We presume the offending dye is coralline, which gained such notoriety a year or so ago. It is impossible to avoid asking whether the sale of such dangerous articles cannot be stopped. The color is attractive, and just now is fashionable; any one, however, who has respect for his 'poor feet' would certainly be wise to avoid it."

A BILL for regulating the practice of vivisection has been introduced into the British Parliament. It proposes to enact that after January, 1876, vivisection is only to be performed in places duly registered, and upon notice being given to the Secretary of State. Anæsthetics are always to be employed, except when a special license has been granted by the Secretary. The penalty for an offense against the act is not to exceed £20.

THE library of the late J. J. Audubon, containing 800 volumes, was destroyed by fire at Shelbyville, Kentucky, on April 29th.

JULIUS E. HILGARD.